



Vol. XXXVII, No. 7

Whole No. 324

October, 1937

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINERADDER



**A Journal
for all
SCIENCE AND
MATHEMATICS
TEACHERS**

CONTENTS:

Nature Recreation
Science and Education
Laboratory Work in Science
Increasing Pupil Participation
Tooth Decay: Its Cause and Prevention
A Program of Socialization for Biology

Published by THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.
Publication Office: 450 ANNAIR ST., MENASHA, WISCONSIN

Business Manager: 450 ANNAIR ST., MENASHA, WISCONSIN, AND 3319 NORTH
FOURTEENTH ST., MILWAUKEE, WISCONSIN

Editorial Office: 7633 CALUMET AVENUE, CHICAGO, ILLINOIS

Published Monthly, October to June, inclusive, at Menasha, Wisconsin. Price \$2.50 per
year: 35 cents per copy. Entered as second class matter December 8, 1932, at Menasha,
Wisconsin, under the Act of March 3, 1879.

TURTOX FOR BIOLOGY

**PRESERVED MATERIAL
DEMONSTRATION MOUNTS
APPARATUS
LANTERN SLIDES**

**MICROSCOPE SLIDES
SKELETONS
LIVING FORMS
CHARTS AND MODELS**

Highest quality, prompt service and a desire to contribute to the teaching of the Biological Sciences have done much to make Turtox the leader in Biology.

*Ask for your copy of the 300-page TURTOX Biology
Catalog and Teachers Manual*



*The Sign of the Turtox
Pledges Absolute
Satisfaction*

GENERAL BIOLOGICAL SUPPLY HOUSE

Incorporated

761-763 EAST SIXTY-NINTH PLACE

CHICAGO



INSTRUMENTS OF DEPENDABILITY *for every need...*

MODEL 622—Ultra-Sensitive Microammeters, Millivoltmeters
Double pivoted type instruments—requiring no leveling—for measurement of minute currents. Low ranges down to 5 microamperes statically shielded. Ranges up to 20 microamperes magnetically and statically shielded. Ideal for laboratory work and circuits involving thermo-couples, pyrometers, electron tubes, etc.

MODEL 430—Portable, Precision A. C. and D. C. Instruments
Universally used in schools and throughout industry wherever rugged, portable instruments are required for general testing. Hand calibrated, mirror scales with knife-edged pointers. Size $5\frac{1}{8} \times 6\frac{3}{8} \times 3\frac{1}{2}$ inches. The line includes D.C. instruments, A.C. instruments and single phase Wattmeters.

*Send for literature describing all WESTON Instruments.
Weston Electrical Instrument Corporation, 583 Freling-
huysen Avenue, Newark, New Jersey.*



WESTON *Instruments*

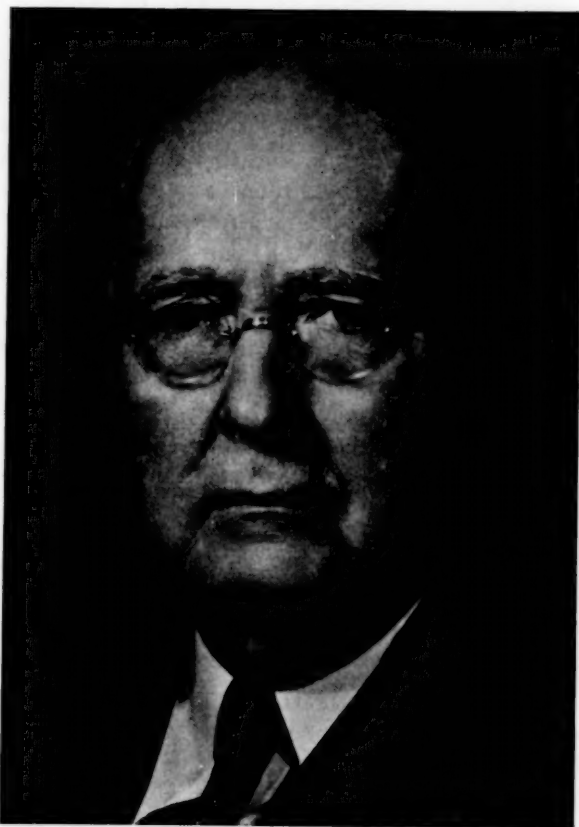
Please Mention School Science and Mathematics when answering Advertisements

SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXVII

OCTOBER, 1937

WHOLE No. 324



CHARLES ELIJAH LINEBARGER

founder of

SCHOOL SCIENCE AND MATHEMATICS

CHARLES ELIJAH LINEBARGER
1867-1937

Charles Elijah Linebarger, founder of SCHOOL SCIENCE AND MATHEMATICS, died at his summer home in Leland, Michigan on July 12, 1937. To his friends and associates Mr. Linebarger will always be remembered as a genial man socially and an outstanding teacher professionally.

After completing his work at Northwestern University in 1897, he studied at Sorbonne in Paris and at Tübingen and Göttingen in Germany. For thirty-five years he was engaged in teaching the Physical Sciences at Lake View High School in Chicago. During the course of these years he wrote five text books and founded two journals, *School Science* and *School Mathematics*, which he edited until 1905. These two journals were then combined to form SCHOOL SCIENCE AND MATHEMATICS. In spite of these extra duties which he had assumed, Mr. Linebarger always found time to associate with his students. He inspired many young men to follow in his footsteps.

Besides living a full life in his profession, Mr. Linebarger established an enviable reputation as a designer of laboratory apparatus. He originated and patented a balance which later led to the standard triple beam balance. He patented and improved the form of the Joly Balance and wrote a manual of experiments built around this piece of apparatus. He invented the ball type battery hydrometer which was a household article in the days of battery radios. These and other products led him to form the Chaslyn Company, Inc., which is now operated by his son.

HERBERT ELLSWORTH SLAUGHT
1862-1937

Professor Herbert Ellsworth Slaughter, emeritus professor of mathematics of the University of Chicago, died on May 21, 1937, in his seventy-sixth year. He was for many years secretary of the Chicago Section of the American Mathematical Society, as it was then called, and a member of the Council of the Society. From the year 1912 he was active in the development of the *American Mathematical Monthly* and in the organization and promotion of the Mathematical Association of America, of which association he was an officer from the date of its founding, president for the year 1919 and since December 1933 honorary president and life member. He was an honorary

member of the Central Association of Science and Mathematics Teachers. He was also active in the founding of the National Council of Teachers of Mathematics, for a long term a member of the executive committee and in recent years honorary president.

FRANK O. KRUH
1889-1937

With great regret we announce the death of Mr. Frank O. Kruh, chemistry teacher in the Soldan High School, St. Louis and a prominent member of the Central Association of Science and Mathematics Teachers. Mr. Kruh was born in New York State in 1889, received his high school education at Doane Academy and his college work at Syracuse University and Dennison University, graduating from the latter institution in 1916. Later he was granted the M.A. degree from Washington University. He taught first at Rushville, Illinois, then at Roanoke in the same state, and later at Wichita, Kansas. He left Wichita to enter the army for service in the World War. Since his discharge in 1918 he has been a member of the Soldan faculty. At the time of his death he represented Missouri on the Membership Committee of the Central Association. He was also a member of the N.E.A. and of Kappa Delta Pi.

STAFF CHANGES

Due to his many duties as Assistant Principal of Shortridge High School Mr. Joel W. Hadley has found it necessary to give up his work as zoology editor. Mr. Hadley has held this place for the past eight years and has given ample evidence of his good judgment and editorial ability. This place on the staff will now be filled by Mr. Lyle F. Stewart of the Oak Park-River Forest Township High School, Oak Park, Ill. Mr. Stewart will be remembered by all our readers for his excellent article in the June issue on "Trees and Forest Conservation." He has received the A.B. and M.S. degrees at the University of Illinois where he specialized in zoology, botany, and chemistry, giving major attention to ecology in his graduate work. He has also studied marine ecology at Puget Sound Biological Station and has spent two summers in the graduate departments of education and psychology at the University of Wisconsin. This past summer he studied at Northwestern University. His ability in both course work and research is recognized. He has won recognition as a teacher of ability and has a thorough understanding of the present day aims of high school science.

A new department, Science Demonstrations, has been added to our list and is in charge of Mr. Clarence Radius of the RCA Institutes, Inc. Mr. Radius is a graduate of the University of Chicago and has continued graduate work there for a number of years. His training includes the foundation courses in nearly all branches of science, mathematics, and

education. His teaching experience covers work in chemistry, physics, and mathematics at the Englewood Standard Evening High School, Chicago, the Chicago Christian College, and the RCA Institutes. He has also spent several months in the employ of one of the leading scientific apparatus companies, where he has given particular attention to the development of demonstration apparatus. He will have charge of articles describing demonstrations and teaching devices in all branches of science and mathematics. In this issue he has contributed the sketch of the founder of this journal, and a number of book reviews.

DR. ROLLER PROMOTED

At the beginning of this school year Dr. Duane Roller, Editor for Research in Physics, transferred from the University of Oklahoma to Hunter College, New York City, where he now has the rank of Associate Professor of Physics. During the past year Professor Roller has been on leave of absence from Oklahoma working as a research associate in Columbia University. This work, financed by the General Education Board through Teachers College, has been compiling and developing physical science material for use in general education on both college and secondary school levels. Professor Roller will continue his editorial work on this Journal and also as Editor-in-Chief of *The American Physics Teacher*.

EDITOR FRANK B. WADE HONORED

At the 99th commencement of Wabash College, Crawfordsville, Indiana, the honorary degree of Doctor of Science was conferred on our Chemistry Editor, Frank B. Wade, Head of the Chemistry Department of Shortridge High School, Indianapolis, in recognition of his many achievements in the field of chemistry. Dr. Wade is known throughout the country for his contributions to commercial chemistry, his work on natural and synthetic gems, and his books and articles on the teaching of science.

MR. CARPENTER VISITS JAPAN

Mr. Harry A. Carpenter, Elementary Science Editor, spent the summer in the Orient where his particular interest was the meetings of the World Federation of Education Associations. Of his trip he writes as follows:

"Some of us succeeded in getting to Shanghai, although we were not permitted to go north to Peiping. We spent the time, therefore, going south, visiting Hong Kong, Canton, and Manila.

"We returned to Japan in good time for the meetings of the World Federation of Education Associations. Two things stand out in my mind with respect to this meeting:

"1. In the Section on Educational Broadcasting it was disclosed that Japan is devoting a great amount of effort and time to educational broadcasts sent direct to the schools, more than half of the 25,000 schools in Japan being equipped to receive them. This number is rapidly increasing. Great Britain, of course, has been doing a great deal of educational broadcasting, although as I understand it their broadcasting is not an integral part of a particular course of study, as is ours in Rochester. Some broadcasting to schools is also being carried on in Australia, and efforts are being made to include this work in several other countries, Manila, India, and Siam among them.

"2. For the first time in the history of the World Conference there was a science program. We had three half-day meetings, each of which was

attended by 150 to 300 teachers, most of them Japanese teachers. However, there were representatives from the United States, England, Scotland, Ireland, Korea, India, Philippine Islands, Siam, and other countries.

"The group voted to continue the section tentatively as the International Association of Science Teachers, a section of the World Federation of Education Associations. Dr. Otis W. Caldwell was elected Chairman, and I was elected Secretary.

"The Japanese teachers who acted as our guides and companions treated us royally in every way. They are a cultured, happy lot, and are, I believe, doing a splendid educational job. Naturally, the unfortunate circumstances happening in China at the time of the conference served as a depressant in some ways. However, this was not especially apparent in the meetings.

"It seemed to me that for a group of science teachers from so many different countries to discuss common problems was a distinctly worthwhile thing. I feel sure that good will and confidence was established among those teachers who met in Tokyo."

WPA WORKERS PREPARE BYRD ANTARCTIC DATA FOR PUBLICATION

International interest attaches to the forthcoming publication, probably early in 1938, of the great mass of meteorological data assembled during the Antarctic expeditions of Rear Admiral Richard E. Byrd.

That these data may be abridged, evaluated and collated for publication, six workers are busy under direction of George Grimminger who served as meteorologist with Byrd's South Polar expeditions. The work is being sponsored by the U. S. Department of Agriculture's Weather Bureau. Salaries and other expenses are being met by the Works Progress Administration. Total cost of the project, which is expected to be completed late in the current year, is set at \$4,500.

The undertaking is called "The Byrd Antarctic Expeditions' Meteorological Report Project." About eight months' time will be consumed to complete the work of reducing, correcting, evaluating and otherwise preparing the mass of data for publication. Headquarters for the project are in Boston, Massachusetts.

The report, when finally published, will be unique. It will be not only the first meteorological report ever published by this Government on the South Polar regions but also the first ever published by any country to include observations made in the upper air over Antarctica by means of balloons, kites and airplanes. No previous Antarctic expedition was equipped to take these observations of air movements and other data concerning the South Polar air currents which breed much of the world's weather.

The data was obtained in temperatures ranging from freezing to 72 degrees below zero. Even during the brief summer, temperatures of South Polar regions rarely rise above an average of 10 degrees above zero.

Meteorologist Grimminger is enthusiastic over the prospective value of the WPA project as a contribution to the furtherance of Antarctic scientific studies and in the making available of these important data to scientists of this and other countries.

Mr. Grimminger, graduate of George Washington University, has had 13 year's experience with the U. S. Weather Bureau. His work started in St. Joseph, Mo., whence he moved to Trenton, N. J. He then did airways meteorological service at Kansas City, Mo. Transferred to Washington, D. C., he engaged in research and investigations of upper-air conditions. He was detailed to accompany Byrd as meteorologist by Prof. C. F. Marvin, former chief of the U. S. Weather Bureau.

BIOGRAPHY AND HISTORY IN SCIENCE TEACHING

BY C. HARRISON DWIGHT

University of Cincinnati, Cincinnati, Ohio

William Buck Dwight (1833–1906). Beloved by his students, a thorough and painstaking observer of natural phenomena, and a careful organizer of scientific data, Professor Dwight might be taken as an example of the best type of American college instructor of the past generation. Born of American parents in Constantinople, he came in 1849 to the United States to study at Yale University. To his brother James and himself is due the credit for the inception of Robert College, Constantinople. After taking the full classical and scientific courses at Yale, Professor Dwight began a long and fruitful teaching career. In 1859 he founded the Englewood Female Institute, where he taught for six years. After several years spent in mining explorations in Virginia and Missouri, he went to West Point as instructor of the school for the children of the officers stationed there. From 1870 to 1878 Professor Dwight was associated with the State Normal School, New Britain, Connecticut, and from 1880 until the close of his life served as professor of geology and curator of the museum, at Vassar College. In 1891 he invented a petrotome, or rock-slicing machine, which was awarded a bronze medal at Paris. Regarding geology as his major interest, Professor Dwight served as university examiner in that subject for the State of New York, discovered fossils in the Wappinger Limestone, Dutchess County, describing them later to the Smithsonian Institution for the New York State Geological Survey, and was co-editor with Dr. N. S. Shaler of Harvard University of the topic *geology* in the *Standard Dictionary*. Professor Dwight was a member of the teaching staff of the first Summer School inaugurated in this country, the one situated on the island of Martha's Vineyard. He was interested in all phases of natural philosophy, was an early possessor of a sample of radium salt, and had the happy gift of being able to convey scientific knowledge simply and interestingly to the inquiring layman. Once when a child asked him whether a certain sea creature squirming in a specimen jar "*knew* he was a periwinkle," the sage reply was that if we could answer that question, we would solve one of the greatest questions confronting mankind! Did the child know *he* was a child?

A PROGRAM OF SOCIALIZATION FOR BIOLOGY*

BY JOHN EDWIN COE

Lake View High School, Chicago, Ill.

It is evident that the American High School of the future must meet the following changing conditions; due to the mechanism of industry and the deep seated belief of the American people in the value of secondary education, the high schools will have to care for all the children of the age group, fourteen to eighteen years, and since those who, because of mental slowness or physical incapacity, are below their average age rank in attainment, must be retained in school, some means must be sought of making their stay worth while to themselves and to the community. Due to the declining birth rate and the consequent reversal in population trend, there is before us a relief of the "depression crowding" of the schools which will lead to a stabilization or possible decline in high school enrollment.

These changes in the character of the school population have emphasized the importance of directing the attention of the pupil to better methods of enjoyment of leisure time and to a deeper appreciation of the opportunities and obligations of citizenship. There has become necessary a revision of the objectives, the contents, and the methods of instruction used in the various high school courses. There is a widespread feeling among leaders in secondary education that the courses should introduce as many life situations as possible and that the instruction should provide for individual differences as well as for guidance.

Building upon the foundation of nature study in the grades and general science in the first year of the high school, biology interprets for the student his inner life, his physical being, his life processes in health and disease, his attitude toward sex, his relations to animate life and to the society in which he lives.

The great biological principles can be included under a few headings: Morphology, the study of form; Physiology, the study of function; Taxonomy; the study of classification; and Applied Biology. Of these Morphology and Taxonomy should receive but little emphasis but should give the foundation for the great subdivisions of Physiology; namely,

Food & Metabolism

Growth & Reproduction

Inheritance & Eugenics

* Read before the Biological Science Center, March 18, 1937

Environment & Adaptation
Pathology & Hygiene
Paleontology & Evolution
Behaviorism & the Mind

Applied Biology or control of the Environment, especially from the standpoint of man's social behavior and the possibility of attainment of higher levels of human welfare, should have greater emphasis. Because of the large amount of material available, each topic introduced must be chosen on the basis of its value in training in the scientific method, its vocational or avocational bearing, or its basis for training in better citizenship. Any attempt at socialization of instruction must include both the interpretation of the social surroundings and the elaboration of methods to be used in the classroom.

Our change in ideals due to national maturity makes necessary a new formulation of the philosophy of Democracy. These ideals include in economics—that of plenty; in culture—that each individual should have a chance to express his individuality; in education—the kinetic concept of growth. The democratic ideal postulates the “rule of the majority, with the secondary principles of toleration of the opinion of minorities, and the freedom of thought, speech and assembly.”

The development of strong personalities necessitates the emphasis of the ideals of mastery and will or indomitableness. A conflict arises between “rugged individualism” and democratic principles which can be avoided only when the student learns that his highest success comes through the advancement of the group.

The people of Russia, Germany, Italy, France and England and of Japan, each believe that they have found the best way to construct Brigg's state which is “a better place in which to live and in which to make a living.” In the intense nationalism that has arisen amongst these countries with their closure of press and schools to other philosophies than their own, the United States, having won the greatest war in history for Democracy, must now in a positive way train its nationals in democratic ideals. The recent financial depression has taught our people, as no other event in our history, the necessity of working together for the common good.

The determination of the values to democracy of each subdivision and topic of biology will become possible only after much thought, trial and experimentation. For each, there must

be formulated not only general objectives and specific aims but also definite abilities and understandings to be acquired and attitudes and ideals to be attained. A completely new technique for the testing of attitudes and ideals must be worked out. Scientific and creative as well as historical approaches to each problem must be sought.

While socialization in the broadest sense includes any activity leading to "life enrichment through participation," yet in the narrower sense it indicates a definite method. It implies the division of the class into small groups, each with its own organization, for the investigation, preparation and presentation to the class as a whole of some problem or subtopic in which the whole group is interested.

Each individual must in turn make some contribution to the development of the topic, and each should serve his turn as leader of the group. The method includes the preview by the teacher and a possible pretest which may act as a guide in caring for individual differences. Then should follow the planning of the study procedure and choice of problems for investigation, the assignment of problems and activities, the actual preparation of the material for presentation, presentation to the class, general discussion and review, including several types of tests and new vocabulary.

This method is a great consumer of time. The pupils as a rule have had little laboratory training and so, at first, are apt to do inaccurate work in their experiments. With so many groups working on different phases of the topic, securing supplies, equipment and space in which to work is difficult. Those difficulties which are matters of organization can be overcome and care in the assignment of problems will overcome others. In spite of these objections, the skillful teacher will find the method worth trying in those units that are adapted to it.

Within the school, the biology club is another element in social training. This club may have a large membership devoting its time to lectures, debates, films and scientific programmes, or it may be a smaller group working in some special field of their own choice such as microscopy, dissection, paleontology or colloidal chemistry. It should make contact with the State Junior Academy of Science, and plan to have representation and exhibits at their annual meetings.

It is possible in most schools to give one assembly period each term to the presentation of a play or program by the biology

department. There is little literature available on the subject so that it requires considerable time on the part of the teacher and students to work up a suitable program.

In order to use the material available for the teaching of biological applications, a survey of the community is necessary. This survey should include some study of the geography and geology of the area surrounding the school. It should include the state in which the school is located and the nearer parts of surrounding states. In order that certain social aspects of the subject may be emphasized the student should be furnished with maps giving the details of his school district, and on a smaller scale of city parks, county forest reserves, and of all state and national parks, monuments, fish hatcheries and game reserves within two hundred miles of the school. Since at present the student's only source of information of this sort is occasional articles appearing in the daily papers, a systematic and scientifically prepared outline should be furnished him. City, county, state and national officials are very willing to coöperate in furnishing this information. The subject of Conservation of Natural Resources should become a major topic rather than an incidental one.

The Chicago area offers many opportunities for the biology student. He should have definite information concerning the Chicago Academy of Science, the Field Museum, the Museum of Science and Industry, the Trailside Museum, the Shedd Aquarium, the Adler Planetarium, the Lincoln Park and Brookfield Zoological Gardens, the Lincoln Park and Garfield Park Conservatories and the Morton Arboretum. This information should give not only general instructions as to how to reach the institutions but should afford specific details as to the location of exhibits and points of interest. This should enable the student to visit the institution with a definite study in mind so that he will not merely wander about looking at anything of interest.

The following laboratories are well worth study: City Department of Health, with its divisions of food, milk, water and disease control, the U. S. Food Laboratories, State Department of Conservation, and City Sewage Disposal Works. Among private enterprises that give information on special topics are: the Chicago Lighting Institute, the milk bottling plants of the Borden and Bowman Companies, hospital diet kitchens, hospital and commercial laboratories, medical schools, Union Stock

Yards, food and drug factories, and stone quarries and gravel pits.

Throughout the year there is a series of shows including the Stock, Garden, Poultry, Flower and Horse Shows and the Youths Exposition that will interest certain pupils.

Unfortunately there are several real difficulties to be overcome in the use of this material. In order to secure the best results, a study group should be small, probably not over fifteen. A trip to one or more of these institutions requires at least half a day, and since the visit must be on Saturdays or a holiday the most enthusiastic teacher is limited to a few each term. Many of the pupils must make real sacrifices to secure the funds for transportation. The responsibility of the teacher for the pupil's safety is probably legally very great, and it has proven quite hazardous to send female students to any distance unaccompanied.

Another group of social activities which are open to the students are the public lectures given weekly at the Chicago Academy and at the Field Museum. These museums, also, offer use of special libraries and of directed tours. The organization and activities of such groups as the Audubon Society, the Amateur Geologists, the Microscopical Society, the Lion's Club, the Waltonian Society, the Prairie Club, the Boy Scouts and Camp Fire Girls, and the Conservation Council should be formulated and placed in the hands of the pupil. The high school biology club or some interested group might well publish a monthly summary of the announced programs of these groups and distribute it through the teachers to the pupils. Such a publication could, also, afford a fine outlet for the review of new books, the discussion of scientific discoveries, and current topics of biological interest. It could well make use of all the artistic and literary ability of the members of the club.

In the biology classes a high percentage of the students expect to make some form of applied biology their life work. Early in the term, information should be sought (in addition to the intelligence quotients, placement tests, and reading ability furnished in general guidance) concerning those students who expect to enter the medical, dental, laboratory-technician, pharmacy, nursing, or dietetic professions or who expect to become museum or research workers or teachers of biology. An exploratory survey of these fields with assignment of special topics and activities would assist such students to orient them-

selves. Attention should also be called to the wide range of fields in applied biology such as the national and state services of biological survey, forest and park ranger, conservation, plant inspection and breeding, water, meat, food and drug inspection, geology, entomology and public health; the special sciences of the universities such as botany, zoology and geology, archaeology, ethnology, anthropology, ornithology, herpetology and mammology; and to such private enterprises as the production, manufacture and distribution of foods, drugs and clothing, gardening and fruit growing, nursery, green house, florist shop and seed store management, landscape gardening and tree surgery, agri-, api-, avi-, and aquiculture, game and fur farming.

Every student in biology should carry away from the course an interest in one or more fields which he can convert into a hobby that will be, as an avocation, a life-long source of enjoyment and enrichment of living. In order to orient the student in such activities he should be furnished with lists of the more important flora and fauna. These should include the following plant groups: trees, shrubs and perennials, wild and cultivated flowers, fruits, grasses, vegetables, algae, mushrooms, mosses and ferns and their allies; and such animal groups as birds, fish, reptiles and amphibians, mammals, insects, protozoa, domesticated animals and fowls. These lists should be fully illustrated and contain simple keys, together with adequate description. Probably one day a week throughout the term should be devoted to this work with special emphasis upon trees, weeds and insects in the autumn, and upon birds and wild flowers in the spring. These lists and descriptions should be printed on paper of notebook size so that they can be issued as needed and should be retained by the pupil at the end of the course. Once assembled, this material could be used for many years with occasional revision. Work on vertebrate embryology, mental hygiene and the learning process, anthropology and human biology should be formulated and added to the course.

While the many practical applications of biological principles will remain an important reason for the retention of biology in the curriculum, biology must now do its part along with other agencies in school and outside in inculcating democratic ideals.

We may well make use of the methods that have been developed recently in Europe toward the strengthening of na-

tionalism. As Merriam has shown, these include the use of language and literature, symbolism, love of locality, important traditions, biography and aspirations. Much of this material requires formulation, but because of the world leadership of America in biology, this may well be the first of the high school subjects to attempt such reorganization.

Biology should emphasize biography especially of our nationals who have developed the field. The story of a Burbank, or a Jordan or a Babcock might well be contrasted with that of a Bismarck or a Napoleon. Perhaps no better example of devotion to the democratic ideal can be found than in the method by which the great research foundation of the University of Wisconsin was established.

Since the love of locality can best be induced by a study of that locality, a project on the interpretation of local and national geology and geography as affecting our social structure should be introduced into our course.

Due to the universality of its fields of interest and to its meeting great categories of social, civic, vocational and avocational needs it would seem that all students and not merely the forty percent who now do so, should receive training in biology. The recently published "Functions of Secondary Education" states "work in the natural sciences, especially in biology, and in all the arts, . . . seems to be due for enormous expansion when the secondary school curriculum really begins to be built around pupil's developing interests. These fields have enormous educative possibilities which have only begun to be utilized."

APPRAISAL OF INSTRUCTIONAL MATERIAL

For the first time in the history of education in America, instructional materials such as textbooks and courses of study are being carefully evaluated and the results given national circulation. These evaluations are contained in a new feature of the *Education Digest* called "The Education Digest Ratings of Instructional Materials" which made its first appearance in the June issue of the magazine published at Ann Arbor, Michigan.

Because the superabundance of instructional materials makes it difficult for educators to choose materials best suited to their needs, the editors of the *Education Digest* are seeking to help solve this problem by providing ratings on a five-point scale for various instructional items. The ratings are made by experts selected on a nation-wide basis.

The textbooks, etc., are rated on content, workmanship, interest, teachability, and attractiveness. All fields of education from preschool through teacher-training are represented in the items rated. Several psychological tests were rated for efficiency in the September issue.

APPLICATION OF PROFESSIONAL TREATMENT TO LOGARITHMS

PART III

BY EUCEBIA SHULER

Georgia Southwestern College, Americus, Georgia

THE HISTORY OF LOGARITHMS AND THE SLIDE RULE

The original concept of the logarithm was derived from the comparison of a geometric and an arithmetic series, both of which were taken arbitrarily; the members of which, however were closely coordinated with each other. The arithmetic series gave the logarithms, the geometric series the numbers.¹ One might read from a passage in Archimedes (c. 225 B.C.) *Sand Reckoner* the fundamental logarithmic rule for the multiplication of two numbers. He observed that in the series 1, a^1 , a^2 , a^3 , a^4 , a^5 , a^6 , a^7 , . . . if the third term, a^2 , is multiplied by the sixth term, a^5 , that the product is a^7 , which is again a term of the series; and that the number of the term, a^7 , is eight, which is one less than the sum of the series numbers three and six.² If these Archimedian series numbers were not different by one from our exponents, Archimedes would have given, even verbatim, our formula $a^m \cdot a^n = a^{m+n}$. The most important improvement came when the above series numbers were lowered by one and the laws of exponents were made possible.³ Although this ancient mathematician came so near to establishing the laws of exponents as they are known today, there elapsed a period of about 1900 years before Newton (1669) made them universally known and understood. Not only were the laws of exponents late in developing, but they were known in theory long before they were used in actual practice. It is possible that, if Archimedes had developed his idea a little more completely, logarithms would have appeared much sooner and would have proceeded naturally from the theory of exponents. Probably the best treatment of exponents, even as late as the 15th century, was given by Chuquet (1484); but he used $12^\circ = 12$, and 12^2 for $12x^2$. He also showed that he had an idea of negative exponents by using $\cdot 9^3 \cdot \tilde{m}$ for $9x^{-3}$.⁴

¹ Johannes Tropicke, *Geschichte der Elementar-Mathematik*, Berlin, Walter De Gruyter and Co., 1922, 2, 169.

² *Ibid.*

³ Tropicke, *op. cit.*, 2, 169-170.

G. A. Miller, "Did John Napier Invent Logarithms?" *Science* (1929), 70, 97.

⁴ D. E. Smith, *History of Mathematics*, New York, Ginn and Co., 1923, 2, 414. Tropicke, *op. cit.*, 2, 170.

The laws of exponents as expressed by Chuquet were given in connection with the double series

$$\begin{array}{cccccc} 0 & 1 & 2 & 3 & 4 & 5 \dots \\ 1 & a & a^2 & a^3 & a^4 & a^5 \dots \end{array}$$

which was used by Archimedes. Probably the first time the principle of multiplication was set forth in print using this notion of exponents was by Rudolff (1526) in *Künstliche Rechnung*. Because of its influence on later mathematicians it is very important.⁵

The next advance made in the study was made by Stifel (1544) in his work, *Arithmetica Integra*, in which he used the two series referred to above, extended them to include negative numbers and hence negative exponents; distinctly called the numbers in the arithmetic series the *exponents*; and gave the laws of exponents in multiplication and division. Others of this period recognized this law of exponents, but no great additional information was given beyond that presented by Stifel.

Napier (1614) is considered the outstanding contributor in the development of logarithms. His invention was the result of at least twenty years of work and was perhaps entirely his own original idea. He was impressed with the difficulties of calculation in connection with astronomical studies and set about finding a method to shorten the work. With this idea in mind he may have been led to see the laws of logarithms by the formula⁶

$$\sin A \sin B = \frac{1}{2} [\cos (A - B) - \cos (A + B)]$$

which suggests multiplication by means of addition. Napier's approach was geometric and had no connection with the laws of exponents. In fact, exponents were not universally known and accepted as a means of computation at this time; it was a half century yet before they were generally established. Other handicaps lay in the fact that algebra was still in a primitive state, that the function concept was unknown, and that decimal fractions, characterized by awkward symbols, had just been discovered.⁷

Napier first used the term "artificial number" to refer to his invention, but later applied the word "logarithm" meaning

⁵ Smith, *op. cit.*, 2, 520.

⁶ Smith, *op. cit.*, 2, 514.

⁷ F. E. Andrews, "The Romance of Logarithms," *SCHOOL SCIENCE AND MATHEMATICS* (1928), 28, 122.

G. Chrystal, *Algebra*, London, Adam and Charles Black, 1904, 530.

"ratio number." He first sought the logarithm of sines and defined them as velocities of two moving points.⁸ The base of Napier's logarithms was not e , as it is sometimes stated, and the present natural or Napierian logarithms are not the same as those invented by him; but they may be connected with his system by a formula.⁹ Napier's logarithms increased as the number decreased, the logarithm of $\sin 90^\circ = 0$, the logarithm of $10^7 = 0$, $\log (10^7 - 1) = 1$, and the system had no base.¹⁰

Henry Briggs, after reading Napier's *Descriptio* (1614), planned to visit him. In 1615 he spent a month in conference with Napier and as a result the present system of logarithms to the base 10 evolved. This change greatly simplified calculations and in 1620 Gunter published the first table of logarithms of trigonometric functions.¹¹

Bürgi (1620) seems to have developed logarithms independently through the idea of exponents by using two series similar to those of Archimedes. In 1620 he published *Progress Tabulen* at Prague. The tables are lists of antilogarithms with base 1.0001. The logarithms are printed in red and the antilogarithms in black, hence the name *Die Rothe Zahl*.¹²

Euler (1707-1783), when twenty or twenty-one years old, suggested e to stand for $2.718 \dots$, the base of the natural or Napierian system of logarithms¹³ used in higher mathematics. He defined logarithms as exponents and contributed information on the logarithms of negative and imaginary numbers.¹⁴

The word "mantissa,"¹⁵ meaning an "appendix" was introduced by Briggs (1624). It was derived from a Latin word originally meaning an addition or something of minor value. Euler adopted it in 1748 and then it came into general use. The term

⁸ Florian Cajori, "The Logarithms of Napier," *Science* (1927), 65, 547.

Florian Cajori, *A History of Mathematics*, 1924, 149.

⁹ See Smith, *op. cit.*, 2, 516.

Also Florian Cajori, "Talk on Logarithms and Slide Rules," *SCHOOL SCIENCE AND MATHEMATICS* (1920), 20, 527-530.

¹⁰ Philip E. B. Jourdain, "John Napier and the Tercentenary of the Invention of Logarithms," *The Open Court* (1914), 28, No. 9, 513-520.

J. W. L. Glaisher, "Logarithms," *Encyclopaedia Britannica*, Edition 11 (1910), 16, 868. Napier's original formula may be written: $L = 10^7 \log_e 10^7 - 10^7 l$. Ignoring the factor 10^7 , which makes sines and logarithms integral to seven places, the base is e^{-1} when L denotes Napier's logarithms as first invented; l denotes Napierian logarithms which are to the base e .

¹¹ Tropfke, *op. cit.*, 2, 185.

¹² Smith, *op. cit.*, 2, 523.

¹³ D. E. Smith, *A Source Book in Mathematics*, New York, McGraw-Hill Book Co., 1929, 95.

¹⁴ See Florian Cajori, *A History of Mathematics*, New York, The Macmillan Co., 1924, 235.

¹⁵ Smith (History), *op. cit.*, 2, 514.

"characteristic" was suggested by Briggs (1624) and was used in Vlacq's tables in 1628.¹⁶

Logarithms were introduced into China by the Jesuits, and Vlacq's tables (1628) were reprinted in Peking in 1713.¹⁷ Arithmetic books began giving a treatment of logarithms by the middle of the 17th century, and in this way they came to receive universal recognition.

A slide rule is really a condensed table of logarithms, and its development begins very soon after the invention of the latter. One may easily construct a simple slide rule by laying off to a convenient scale the logarithms of the numbers 1, 2, 3, . . . on two strips of cardboard, and readily solve problems in multiplication and division.

Edmund Gunter (1581-1626) is usually considered the first to make use of logarithmic scales. His slide rule (1620) was a single line marked off in divisions corresponding to the logarithms of numbers, which he added and subtracted by means of dividers.

Oughtred (1632) is the inventor of the slide rule in both the straight and the circular form; however, Delamain, his pupil, claimed to be the first.

Newton (1675) suggested a runner for the slide rule, and he devised a method for solving cubic equations by its use.¹⁸

Mannheim, an artillery officer, in 1850 designed his slide rule which was used by the French artillery. The Mannheim rule is one of the standard slide rules of today. It has been used in the United States since 1890.

Improvements have been made in the rules and the runners so that now very accurate arithmetic, trigonometric, and logarithmic calculations may be made.

Suggested readings on topics similar to the following may prove interesting and instructive to students who wish to study the history of logarithms in greater detail. Others than these may be used to enlarge the list:

1. The history of logarithms.
 - a. Early approaches to logarithms.
 - b. "Napier's Bones" or Napier's Rods and how they are used to multiply.

¹⁶ M. d'Ocagne, "Some Remarks on Logarithms Apropos to Their Tercentenary," *Annual Report of the Smithsonian Institution*, Government Printing Office, Washington (1914), 179-181.

G. A. Miller, "A Wide-Spread Error Relating to Logarithms," *Science* (1926), 64, 279.

¹⁷ Smith (History), *op. cit.*, 2, 514.

¹⁸ Vera Sanford, *A Short History of Mathematics*, New York, Houghton Mifflin Co., 1930, 443.

- c. Contributions of other mathematicians, as Stifel, Chuquet, Frisius, Euler, etc.
- d. Origin of terms.
- e. Biographies of the leading men connected with the history of logarithms.
- 2. Influence of logarithms.
- 3. Different logarithmic systems.
- 4. History and use of the slide rule.
- 5. Calculating machines.

THE HISTORY OF THE TEACHING OF LOGARITHMS

Judging by the history of logarithms and the old texts available for this study, the history of the teaching of logarithms seems to fall roughly into two periods which may be described in the following manner. First, the period from about the middle of the 17th century through the first quarter of the 19th century when logarithms made their first appearance in the elementary arithmetic texts in Great Britain and on the Continent.¹⁹ As early as 1646 they appeared in an edition of *Ground of Arts*.²⁰ The time between 1750 and 1825 may be characterized by the fact that the explanations of logarithms were based largely on the arithmetic and geometric progressions, or on some series.²¹

An examination of several of these texts will be valuable and interesting. The twelfth edition of *The Young Mathematician's Guide* by Ward²² (1771) contains a treatment of logarithms described as "A Supplement not in any of the Former Editions of this Book containing the History of Logarithms with Several Methods of Constructing the Tables of the Logarithms and Sines, etc." His purpose in writing this treatise was "to discover and explain the doctrine of logarithms to those who are not yet beyond the elements of Algebra and Geometry."²³ After a brief introduction there follows a history of logarithms, an explanation of the construction of the tables, and directions for finding the logarithms of numbers. It is interesting to compare the

¹⁹ Smith (History), *op. cit.*, 2, 518.

²⁰ Sanford, *op. cit.*, 197.

²¹ This fact is probably true of the first part of the period, but no text was available through which to verify the supposition.

²² John Ward, *The Young Mathematician's Guide*, London, Printed for J. Beecroft, J. Rivington, and others, 1771, 457-480. In the preface of this book is the following interesting statement: "The use of these (logarithms) every one knows, is of greatest Extent, and runs through all Parts of Mathematics. By their Means it is that Numbers almost infinite, and such as are otherwise impracticable, are managed with Ease and Expedition. By their Assistance the Mariner steers his Vessel, the geometrician investigates the nature of the higher curves, and the Astronomer determines the places of the Stars, the philosopher accounts for other Phenomena of Nature; and lastly, the User computes the Interest of his Money.

²³ Ward, *op. cit.*, 458-459.

several methods which Ward presents for computing logarithms with the relatively simple means used today. The approach to the study is made through the arithmetic and geometric series. There are no exercises in this book proposed for the students' solution and there are no practical applications of the use of logarithms.

In 1808, Emerson²⁴ gave, in the form of a theorem, a short treatment on the problem of finding a logarithm by a series, or of turning numbers into logarithms. The reverse process is also given in the form of a theorem and corollaries.

In *A Course of Mathematics* by Hutton,²⁵ there is a simple explanation of logarithms through the arithmetic and the geometric progressions. Logarithms are defined as "numerical exponents of ratios," as "a series of numbers in arithmetical progression answering to another series of numbers in geometrical progression," and "as the index of that power of some other number which is equal to the given number."

Two clearly explained and illustrated rules are given for finding the logarithm of a number; one method uses the arithmetic and geometric means, and the other a series.²⁶

The texts of this time seem to give no application of the study, no exercises, and no problems for students to solve. In the text by Hutton there are four examples proposed for the student.

The second period, extending from about 1825 to the present, may be described as the time when logarithms are approached through the theory of exponents. There is an interesting book of tables (1819) by François Callet²⁷ in which the theory is presented very simply. *Mathematics for Practical Men* by Gregory²⁸ (1825) contains a short section on logarithms, which treatment is more nearly like that usually given today. Exponents are used to explain the theory, develop the formulas, and to show how to change from one base to another. By 1848, when Francis H. Smith²⁹ published *An Elementary Treatise on Algebra*, there is found very little difference in the explanations and treatment of logarithms from that which is given in modern

²⁴ William Emerson, *A Treatise of Algebra*, London, Printed for F. Wingrave, 1808, 244-247.

²⁵ Charles Hutton, *A Course of Mathematics* (Revised and corrected by Robert Adrian), New York, Samuel Campbell, William Falconer, T. and J. Swords, and others, 1812, I, 155-156, 159.

²⁶ Hutton, *Ibid.*, 161.

²⁷ François Callet, *Tables Portatives De Logarithms*, Paris, Firmin Didot, 1819, 9.

²⁸ Alinthus Gregory, *Mathematics for Practical Men*, London, Printed for Baldwin, Cradock, and Joy, 1825, 97-99.

²⁹ Francis H. Smith, *An Elementary Treatise on Algebra*, Philadelphia, Thomas Cowperwait and Co., 1848, 259-273.

texts. The series explanation of theory has entirely disappeared, and sufficient examples for drill and practice have appeared.

There was no complete and adequate treatment of the theory of exponents given in any of the old books preceding 1848, which are mentioned in this discussion. The usual way in which that topic was handled amounted to a statement of the rules concerning involution and evolution followed by a few illustrative examples. In each book examined, except one, the theory of exponents preceded the study of logarithms.

Although logarithms were hailed as a labor saving device, the early textbooks in algebra seemed to present the theory as a kind of supplementary topic to be studied, but little effort was made to apply the theory to concrete problems or to show practical applications.

The Slide Rule in Textbooks. In a discussion on the necessary knowledge for one engaged in practical gauging, Ward mentions the slide rule in the following connection:

In arithmetic he (the practical gauger) should understand the practical Rules very well . . . both in whole Numbers and Decimal Parts, that he may be ready at computing the Contents of any vessel . . . by the Pen only, viz. without the Help of those Lines of Numbers upon Sliding Rules, so much applauded, and but too much practised, which at best do but help guess at the Truth. . . . 'Tis true, when the Rules are made two or three Foot long (I had one six Foot) there they may be of some use, especially in small numbers; Although even then the operations may be much better (and almost as soon) done by the Pen; For, indeed, the chief Use of Sliding Rules is only in taking of Dimensions, and for that Purpose they are very convenient.³⁰

John Potter in his *System of Practical Mathematics* (1753) devoted three pages to the slide rule and said that it might be used to correct mistakes. Nicholas Pike in his third edition of *Arithmetic* (1809) tells how to solve problems by Gunter's Scales.³¹

Palmers' *Computing Scale*, one of the earliest American slide rules, appeared in Boston in 1844. It was a circular rule eight inches in diameter, thus providing a scale about twenty-five inches long.³² The slide rule was little known before 1880, and was mentioned only occasionally.

After the Mannheim rule came into use (1880), it was made a part of the required courses in mathematics and engineering at

³⁰ Ward, *op. cit.*, 433.

³¹ Sanford, *op. cit.*, 349-350.

³² J. E. Thompson, *A Manual of the Slide Rule*, New York, D. Van Nostrand Company, 1930, 17.

Washington University, in St. Louis;³³ now it is frequently taught in connection with high school and college mathematics.

THE THEORY OF LOGARITHMS

It was learned in the history of logarithms that the invention grew out of a comparison of an arithmetic and a geometric series of numbers. If the general form of the geometric progression is used as:

(1) $a, ar, ar^2, ar^3, \dots, ar^{n-1}$,
 then (2) $\log a, \log ar, \log ar^2, \log ar^3, \dots, \log ar^{n-1}$
 are in an arithmetic progression.

A concrete series of the powers of 2 will illustrate:

1	2	3	4	5	6	...
2	4	8	16	32	64	...

which may be written in one series thus

$$2^1 \quad 2^2 \quad 2^3 \quad 2^4 \quad 2^5 \quad 2^6 \dots$$

It is easily shown that the product of any two of these numbers may be found by using the law of exponents. Hence, multiplication is reduced to the process of addition, division to subtraction, raising a number to a power to multiplication, and so on.

The same series may be put in logarithmic form and the concept of a logarithm developed so that a definition naturally follows. Each of the laws of exponents may be associated with the corresponding logarithmic processes and general laws for their operations formulated. The following suggestion is made with regard to the logarithm of a product:

Exponential Form	Logarithmic Form
$2^3 = 8$	$\log_2 8 = 3$
$2^4 = 16$	$\log_2 16 = 4$
$2^3 \cdot 2^4 = 8 \cdot 16$	$\log_2 (8 \cdot 16) = \log_2 8 + \log_2 16$
$2^7 = 128$	$\log_2 128 = 3 + 4 = 7$
General Exponential Form	General Logarithmic Form
$b^m \cdot b^n = b^{m+n}$	$\log_b (m \cdot n) = \log_b m + \log_b n$

To bring out the fact that the logarithm of a number is a function of the base, a table of powers of 4 may be set up; from this it is seen that the $\log_4 64 = 3$, whereas from the table of

³³ Thompson, *op. cit.*

powers of 2 the $\log_2 64 = 6$. This idea may be enlarged upon as far as needed.

In the same manner as above, the other laws of exponents may be associated with logarithms.

It may be well at this point to give attention to the fact that the logarithm of zero is infinite and that a negative number has no real logarithm. Suppose b is greater than zero; then in the equation $b^x = n$, if b is greater than zero and less than 1, x must approach positive infinity as n approaches zero; or if b is greater than 1, x must approach negative infinity as n approaches zero; hence there is no finite value of x which will satisfy the equation $b^x = 0$ for b greater than zero. In like manner, if b is positive for all real values of x , then the equation $b^x = n$ is impossible if n is negative. The graph $y = \log x$ will show this very clearly.

These explanations take care of numbers which may be expressed as rational powers of a given base b greater than zero. Analogous statements may be made for b less than zero.

Often it is impossible to express a desired number as a rational power of a base. Suppose it is desired to find the exponent of the base 2 which will give 14. Consult the table of powers of 2 and note that the exponent, which may be designated by x , will lie between 3 and 4.

	x	N
$2^3 = 8$	3.	8.
$2^{3/2} = 2^3 \cdot 2^{1/2} = 8\sqrt{2} = 11.32$	3.500	11.32
$2^{11/3} = 2^3 \cdot 2^{2/3} = 8\sqrt[3]{4} = 12.70$	3.667	12.70
$2^{15/4} = 2^3 \cdot 2^{3/4} = 8\sqrt[4]{8} = 13.43$	3.750	13.43
$2^{91/24} = 2^3 \cdot 2^{2/3} \cdot 2^{1/8} = 8\sqrt[3]{4}\sqrt[8]{2} = 13.89$	3.792	13.89
$2^{23/6} = 2^3 \cdot 2^{5/6} = 8\sqrt[6]{2^5} = 14.26$	3.833	14.26 ³⁴

Thus it is shown that x lies between $91/24$ and $23/6$ or between 3.792 and 3.833. If x is taken equal to 3.81, then $2^{3.81}$ is approximately 14.

Logarithms which are usually used for ordinary computations are to the base 10, since our number system is a decimal one. To apply the concepts that have already been learned to logarithms having the base 10, the pupils may be required to construct a table of decimal powers³⁵ of 10 by extracting suc-

³⁴ Mayme I. Logsdon, *Elementary Mathematical Analysis*, New York, McGraw-Hill Book Co. 1932, I, 66, 67.

³⁵ Barnet Rudman, "Teaching of Logarithms to High School Pupils in Eight Recitation Periods." *The Mathematics Teacher* (1926), 19, 457.

cessive square roots:

$$10^{1/4} = (10^{1/2})^{1/2} = \sqrt{\sqrt{10}} = 1.778$$

$$10^{2/4} = 10^{1/2} = \sqrt{10} = 3.162$$

$$10^{3/4} = \sqrt[4]{1000} = \sqrt{\sqrt{1000}} = 5.623$$

$$10^{5/4} = 10\sqrt[4]{10} = 10\sqrt{\sqrt{10}} = 17.782$$

Exponential Form

$$10^0 = 1.000$$

$$10^{0.25} = 1.778$$

$$10^{0.50} = 3.162$$

$$10^{0.75} = 5.623$$

$$10^{1.00} = 10.000$$

$$10^{1.25} = 17.782$$

Logarithmic Form

$$\log 1.000 = 0.00$$

$$\log 1.778 = 0.27$$

$$\log 3.162 = 0.50$$

$$\log 5.623 = 0.75$$

$$\log 10.000 = 1.00$$

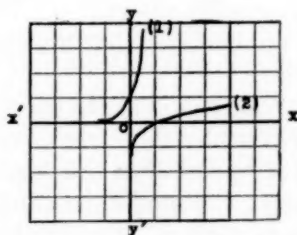
$$\log 17.782 = 1.25$$

A continuation of such tables for larger positive exponents and for negative exponents will present the opportunity to develop the rules regarding the characteristics of logarithms of numbers greater than one and less than one.

Other powers of 10 which lie between 10^0 and $10^{1.25}$ may be found approximately, but for the best results tables should be constructed so that the successive exponents differ by very small amounts.

THE GRAPH OF THE LOGARITHMIC FUNCTION

Rectangular Scales. Consider the table of powers of 10 expressed by the general formula $y = 10^x$ or $x = \log_{10} y$ and graph the function. From the graph there may be determined approximate values of x for corresponding values of y and *vice versa*. The graph may also be used to multiply, divide, raise numbers to higher powers, and extract roots just as the tables of powers of numbers were used.



$$(1) y = 10^x$$

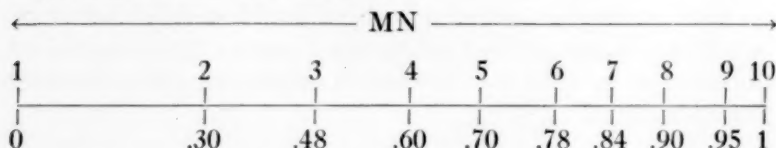
$$(2) y = \log_{10} x$$

Further practice in graphing may be secured by having students put on the same graph the curve represented by $y=b^x$ when the base, b , is changed; and by graphing the inverse function $y=\log_b x$ with corresponding changes in the base. This is another chance to emphasize the functional relationship between two variables.

Logarithmic Scales. So far the scales used in graphing have been rectangular, the same kind of unit has been used on both axes, and the points of division have been uniformly spaced. The logarithmic scale differs from the rectangular and is really a table of logarithms applied to units of length. The following series give the numbers from 1 to 10 with their corresponding logarithms to two decimal places:

1	2	3	4	5	6	7	8	9	10
0	.30	.48	.60	.70	.78	.84	.90	.95	1

If a unit of length MN be chosen, then $MN=1=\log 10$; and if the logarithmic series be plotted on this unit MN , it becomes a logarithmic scale. To make a scale



on which the logarithms of numbers of more than one digit may be found, the scale is made longer and each subdivision of MN is divided in like manner. This will give a logarithmic scale for finding the logarithms of numbers of two digits. The process of subdivision may be continued to obtain a scale of desired accuracy. This is the principle on which the slide rule is constructed. In fact, if the above scale is put on two strips of cardboard or wood so that they slide on each other it will be a slide rule. One may readily see that the laws of exponents or logarithms are here applied and that multiplication is reduced to addition, and so on.

If the logarithmic scale is applied to the y axis and the x axis retains its rectangular scale, there result semi-logarithmic coordinates, and to every point P in this plane there correspond two numbers, $(x, \log y)$, the semi-logarithmic coordinates of P . This kind of graph is used in statistical problems. Suppose $y=e^{4x}$, the $(x, \log y)$ -graph will be represented by a straight line. From this graph may be read other values of x and $\log y$.

If a and b are positive constants, the $(x, \log y)$ -graph of $y = ab^x$ is a straight line. This may be proved very simply by putting the exponential equation in logarithmic form as:

$$\log y = \log a + x \log b.$$

If $Y = \log y$, $A = \log a$, and $B = \log b$, then

$$Y = A + Bx$$

which is a linear equation in x and Y , and its graph is a straight line.

Logarithmic coordinates or the log-log coordinates of a point P may be represented on a plane in which both the x and y -axes are divided according to the logarithmic scale. Since there are no real logarithms of numbers less than or equal to zero, neither negative numbers nor zero appear on the $(\log x, \log y)$ -graph of $f(x, y) = 0$. If a and b are constants and a is positive, then the $(\log x, \log y)$ -graph of $y = ax^b$ is a straight line also. The proof of this theorem is similar to the one above and may be worked by the student.

THE USE OF LOGARITHMS

The method of constructing logarithm tables, the reason for using straight line interpolation, schemes for making interpolation clear to the pupil, the development of the formula for the change of the base, exponential equations, the correctness that may be expected from tables of a given number of places, and practical applications are topics that need to be discussed in connection with the study of logarithms. All through the subject attention should be directed to helpful and significant references to other books and to simple devices which will better prepare prospective teachers for making logarithms understandable to high school children. For example, the writer's experience has shown that in teaching the logarithmic solution of problems of the type $N = ab^2/d\sqrt{c}$ much confusion may be avoided and very satisfactory results secured if a complete outline of the solution is required before any computation is allowed. The outline in its simplest form is:

$$\log N = \log a + 2 \log b - (\log d + \frac{1}{2} \log c)$$

$\log a$	=	$\log d$	=
$2 \log b$	=	$\frac{1}{2} \log c$	=
$\log \text{ num.}$	=	$\log \text{ denom.}$	=
$\log \text{ denom.}$	=		

$$\log N =$$
$$N =$$

Extra material, supplementary problems and topics, and outside readings may be required or suggested as time permits. Logarithms is a subject which easily lends itself to the construction of objective tests which teachers and students may devise as means of review and as instruments of self-testing. The wider the experience of the student in the subject-matter and its many professionalizing elements the better the prospects for efficient teaching.

THIRTEENTH ANNUAL CHEMISTRY CONTEST AT RHODE ISLAND STATE COLLEGE

On May 29th occurred the thirteenth Annual Chemistry Contest for high school students which was held at Rhode Island State College, under the auspices of the chemistry staff of that institution. This affair marked the resumption of the series of such contests which had their inception in 1924, and which were carried on each year, with the exception of 1936. The results of these contests were described in a recent issue of the *Journal of Chemical Education*.^{*} This year a total of thirteen schools were represented by teams—nine from within the State of Rhode Island and four from the neighboring State of Connecticut. A total of eighty-three contestants took part in the contest.

The winning team of the schools within the State of Rhode Island was that from Rogers High School in Newport. This team was awarded the new silver trophy known as the Deena trophy, which they must win three years in succession to retain it permanently. The winter of the out-of-state schools was the one from West Haven, Conn. To it was given a trophy similar to the Deena trophy, but somewhat smaller in size. This latter must be won two years in succession to retain it permanently.

While the contest was going on, a seminar was conducted for the benefit of the teachers who accompanied the teams. Dr. R. K. Carleton of the department of chemistry of the college presided and directed the discussion. Other members of the college staff, as well as the visiting secondary school teachers took part. Several topics of interest to both college teachers and secondary school teachers of chemistry, were discussed to the mutual benefit of all. Professor J. W. Ince, Head of the department of Rhode Island State College was general chairman of all the activities of the chemistry department on May 29th, and Dr. R. K. Carleton was chairman of the chemistry contest and the seminar.

^{*} Lessons from Twelve Years of Chemistry Contests, R. K. Carleton and J. W. Ince. *J. Chem. Ed.* 13, 464-468, 1936.

ERRATUM

In the June 1937 issue of this journal, p. 709, Dr. Morris Meister was referred to as "Science Supervisor, New York City Public Schools." This should have read "Supervisor of Science in Junior High Schools, New York City."

MEASURABLE OUTCOMES OF LABORATORY WORK IN SCIENCE: A REVIEW OF EXPERIMENTAL INVESTIGATIONS

BY HENRY W. DUEL

West High School, Minneapolis, Minn.

At the present time the value and efficacy of individual laboratory¹ work in science is being seriously questioned by many educators and by some science teachers themselves. It is generally recognized that individual laboratory work is expensive, both in money and in time; it is more expensive than an equal amount of lecture; and individual laboratory work by the students costs much more than demonstrations of experiments by the instructor. These statements are substantiated by the studies of Coopriders,² Cunningham,³ and Kiebler and Woody⁴ in secondary school science; and in the investigations of the cost of instruction in science made by the Educational Finance Inquiry Commission,⁵ the Joint Board of Higher Curricula,⁶ Lindsay,⁷ and Noll⁸ at the college level. For these reasons it seems desirable to review the experimental studies with respect to the outcomes of laboratory work both at the secondary school and at the college level. Such is the purpose of this article.

A number of investigations have been made with regard to the relative merits of the lecture-demonstration method and the individual laboratory method of instruction in secondary school science. Coopriders⁹ and Johnson¹⁰ compared these

¹ The term "individual laboratory" is here used to designate a method in which the students perform exercises either singly or in small groups.

² J. L. Coopriders. Oral versus Written Instruction and Demonstration versus Individual Work in High School Science. *SCHOOL SCIENCE AND MATHEMATICS*, 22: 838-844. December, 1922.

³ Harry A. Cunningham. Individual Laboratory Work versus Lecture Demonstration in High School Science. *University of Illinois Bulletin No. 18*: pp. 105-107.

⁴ E. W. Kiebler and Clifford Woody. The Individual Laboratory versus the Demonstration Method of Teaching Physics. *Journal of Educational Research*, 7: 50-59. January, 1923.

⁵ Educational Finance Inquiry Commission. *Unit Costs in Higher Education*. XIII, 171.

⁶ Joint Board of Higher Curricula. *The First Biennial Report to the Governor of Washington*, pp. 11, 28. 1919.

⁷ E. E. Lindsay. Laboratory Costs in State Institutions of Higher Learning. *School and Society*, 20: 537-542. October, 1924.

⁸ Victor H. Noll. The Effect of Varying Amounts of Laboratory Work upon Achievement in General Inorganic Chemistry, chap. V, pp. 23-27.

⁹ J. L. Coopriders. Loc. cit.; also, Laboratory Methods in High School Science. *SCHOOL SCIENCE AND MATHEMATICS*, 22: 526-530. June, 1923.

¹⁰ Palmer O. Johnson. A Comparison of the Lecture-Demonstration, Individual Laboratory Experimentation, and Group Laboratory Experimentation Methods of Teaching High School Biology. (Master's thesis, University of Minnesota, 1926.)

TABLE I
SUMMARY OF RESULTS OF INVESTIGATIONS COMPARING THE LECTURE-DEMONSTRATION METHOD AND THE
INDIVIDUAL-LABORATORY METHOD OF INSTRUCTION IN SECONDARY-SCHOOL SCIENCE

	Subject	Number of Laboratory Exercises	Number of Sections	Pupils per Section	Total Number of Pupils ^a	Mean Scores ^a				
						Immediate Tests		Time Intervening	Delayed Tests	
						Lecture Demonstration	Individual Laboratory		Lecture Demonstration	Individual Laboratory
Wiley	Chemistry	3	3	8	24	56.30	56.60	4 wks.	38.30	39.70
Phillips	Physics	—	—	—	—	137. ^a	133. ^a	—	—	—
Cunningham (1)	Botany	13	2	12	24	64.33	61.15	1 mo.	46.10	49.50
Coopridge (1)	Biology	24	3	14	42	72.55	70.80	—	—	—
Kiebler & Woody	Physics	14	2	—	—	60.53	59.58	2 wks.	58.51	59.30
Coopridge (2)	Biology	12	2	17	68	63.76	62.70	1 mo.	34.74	35.09
Anibel (1)	Chemistry	25	4	23	46	60.71	58.45	—	—	—
Anibel (2)	Chemistry	10	2	17	34	71.11	68.35	5 mos.	57.50	60.85
Cunningham (2)	Botany	12	2	10	20	60.30	55.20	3 mos.	30.50	34.60
Carpenter	Chemistry	10	34	—	856	06.4 ^b	03.1 ^b	—	—	—
Walzer	Physics	24	4	20	80	47.00	42.80	—	54.70	47.80
Knox	Chemistry	10	4	21	85	—07 ^b	—618 ^b	—	—375 ^b	—461 ^b
Johnson (1)	Biology	24	3	11	33	51.90	48.87	1 mo.	42.07	41.40
Johnson (2)	Biology	24	3	17	50	66.30	61.76	2-4 wks.	60.16	55.91
Nash & Phillips	Chemistry	—	2	18 & 22 42 & 28	40	34.10 ^c	35.60 ^c	—	—	—
Pugh	Chemistry	—	2	—	70	10% better	—	2 wks.	18.3% better	—
Horton (1)	Chemistry	—	10	Demonstration— Laboratory—	85 379	40.95	43.60	—	—	—
Horton (2)	Chemistry	2	2	25 & 18	43	13.16 ^d	17.51 ^d	—	—	—
Horton (3)	Chemistry	—	2	26 & 29	55	40.69	42.21	—	—	—
Dyer (1)	Physics	1	5	Demonstration— Laboratory—	63 49	8.28	6.69	8 mos.	7.70	7.66
Dyer (2)	Physics	1	5	Demonstration— Laboratory—	63 49	8.60	8.04	8 mos.	6.84	7.35
Dyer (3)	Physics	1	5	Demonstration— Laboratory—	49 63	5.63	4.90	8 mos.	5.155	5.14

^a Except in the case of Carpenter's study, which was carried on in 23 schools, the studies included but one school.

^b Unless otherwise noted these are raw scores.

^c Number of pupils whose answers were complete and correct.

^d These are sigma scores.

^e These scores are in terms of percentage of gain made from the initial test.

^f These scores represent gains made from the initial tests.

methods with classes in biology; Cunningham¹¹ with classes in botany; Anibel,¹² Carpenter,¹³ Horton,¹⁴ Knox,¹⁵ Nash and Phillips,¹⁶ Pugh,¹⁷ and Wiley,¹⁸ with classes in chemistry; and Dyer,¹⁹ Phillips,²⁰ Walter,²¹ and Kiebler and Woody,²² with classes in physics.

In general, the method of conducting these investigations was as follows: On the basis of intelligence tests or such tests and the students' previous grades in science, the students to be instructed were divided into two groups of approximately equal ability. One group was then taught by the lecture-demonstration method and the other, by the individual laboratory method. Carpenter, Dyer, Horton, and Johnson used a rotation procedure; that is, the same students were taught one exercise or set of exercises by the demonstration method and another exercise or set of exercises by the laboratory method. This method of procedure made it possible for them to compare, not only the achievement of two groups taught by two different methods, but also the achievement of the same group taught by two different methods.

At the close of each study, these two groups were given identical tests, and upon the basis of these tests, the comparative efficiency of the two methods was determined. Usually the groups were tested a second time after a considerable

¹¹ Harry A. Cunningham. Loc. cit.; also *Laboratory Methods in Natural Science Teaching*. *SCHOOL SCIENCE AND MATHEMATICS*, 24: 709-715, 848-851. October and November, 1924.

¹² F. G. Anibel. Comparative Effectiveness of the Lecture-Demonstration and Individual Laboratory Methods. *Journal of Educational Research*, 13: 355-365. May, 1926.

¹³ W. W. Carpenter. Certain Phases of the Administration of High-School Chemistry. Teachers College, *Contributions to Education*, No. 191.

¹⁴ Ralph E. Horton. Measurable Outcomes of Individual Laboratory Work in High School Chemistry. Teachers College, *Contributions to Education*, No. 303.

¹⁵ W. W. Knox. The Demonstration Method versus the Laboratory Method of Teaching High School Chemistry. *School Review*, 35: 376-386. May, 1927.

¹⁶ H. B. Nash and M. J. W. Phillips. A Study of the Relative Value of Three Methods of Teaching High School Chemistry. *Journal of Educational Research*, 15: 371-379. May, 1927.

¹⁷ Pugh, David B. A Comparison of the Lecture-Demonstration and Individual Laboratory Methods of Performing Chemistry Experiments, as Measured by Non-Standardized Objective Tests. Reported by Elliot R. Downing. *Methods in Science Teaching*. *Journal of Higher Education*, 2: 316-320. June, 1931.

¹⁸ W. H. Wiley. Experimental Study of Methods of Teaching Chemistry in High School. *Journal of Educational Psychology*, 9: 181-188. April, 1918.

¹⁹ John H. Dyer. An Analysis of Certain Outcomes in the Teaching of Physics in Public High Schools. Doctor's Dissertation. University of Pennsylvania, 1927.

²⁰ F. D. Phillips. A Study of Notebook and Laboratory Work as an Effective Aid in Science Teaching. *School Review*, 28: 451-453. June, 1920.

²¹ C. H. Walter. Can the Demonstration Method be Made as Effective as the Laboratory Method on the Set-up and Happenings in the Experiment. (Master's thesis, University of Chicago, 1926.) Reported by Elliot R. Downing. *Methods in Science Teaching*. *Journal of Higher Education*, 2: 316-320. June, 1931.

²² E. W. Kiebler and Clifford Woody. Loc. cit.

interval; this interval varied in the several studies. The purpose of these delayed tests was to determine the relative efficiency of the two methods in terms of the knowledge retained after the interval. For convenience, the results of these studies are summarized in chronological order in Table I.

The evidence in Table I is strongly in favor of the demonstration method in immediate results. Only three of the twenty studies cited are favorable to the laboratory method; the other seventeen favor the lecture-demonstration method.

With respect to the retention of subject matter, as shown by delayed tests, the evidence is not so clear. Of the fourteen studies cited, seven favor the demonstration method and seven the laboratory method. It is to be noted that the earlier studies consistently favor the laboratory method while all but one of the more recent studies favor the demonstration method. This discrepancy between the results of the earlier and later studies may be due, in some degree, to the sterility of the demonstration method used by the earlier investigators. In general, their procedure in using this method was as follows: The instructor, as he performed the experiment, used the same language given in the laboratory instructions. He avoided any instruction by means of direct exposition. Such procedure is not ordinarily used in conducting a lecture-demonstration. The name itself implies exposition and explanation by the instructor. It does not seem reasonable to expect such a rigidly formal procedure to bring about the values which the lecture-demonstration method is capable of producing. As far as can be ascertained from the reports of their studies, some of the later investigators, namely, Walter, Knox, Johnson, and Dyer, seem to have corrected this faulty technique and to have accompanied their lecture-demonstrations with explanations and discussions.

Carpenter's²³ study is the most thorough and extensive of these investigations. It included 34 different chemistry classes in 23 high schools located in 14 different states. Three methods of teaching laboratory chemistry were compared: (1) the demonstration method, (2) the individual method, in which the students worked singly, (3) the group-of-two method. Achievement was measured by means of ten objective tests constructed on the basis of ten laboratory exercises which were used as an experimental series.

²³ W. W. Carpenter, *Certain Phases of the Administration of High-School Chemistry*. Teachers College, *Contributions to Education* No. 191.

Intelligence scores were furnished for eight classes. These classes were used for further comparisons on the basis of intelligence. "All scores on these eight classes were divided on the basis of the raw Terman (scores) into upper quartile, middle 50 per cent, and lower quartile and again compiled in each of the three divisions under Methods 1, 2, and 3." Such a tabulation made it possible to study the effect of the three methods upon the achievement of students in these three divisions of mental ability.

The results of this investigation indicate "that the majority of students in high-school laboratory chemistry classes, taught by the demonstration method, succeed as well as when they perform the experiment individually, if success is measured by instruments which measure the same abilities as are measured by these tests, namely, specific information and ability to think in terms of chemistry."

There is also an indication that both the demonstration method and the individual laboratory method are superior to the group-of-two method.

The comparisons based on intelligence showed that, with all the methods, students of higher intelligence excelled those of medium intelligence and students of medium intelligence excelled those of lower intelligence. Students of higher intelligence did a little better with the group-of-two method than with the demonstration method and slightly better with the demonstration method than with the individual laboratory method. Apparently the method used made very little difference in the achievement of students in the upper quartile in intelligence. Students of medium and lower intelligence profited more from the demonstration method than from either of the other methods, the order of preference being the demonstration method, the individual laboratory method and the group-of-two method. The results indicate that, in general, the mental ability of the students is a more important factor than the method of instruction used.

Similar studies previously made by Gilbert²⁴ in zoology, by Mayman²⁵ in elementary physics, by Hunter²⁶ in biology, and

²⁴ J. P. Gilbert. An Experiment on Methods of Teaching Zoology. *Journal of Educational Psychology*, 1: 321-332. June, 1910.

²⁵ J. E. Mayman. An Experimental Investigation of the Book Method, Lecture Method, and Experimental Method of Teaching Elementary Science in Elementary Schools. Reported by F. D. Curtis. *A Digest of Investigations in the Teaching of Science*, pp. 30-33.

²⁶ George W. Hunter. An Experiment in the Use of Three Different Methods of Teaching in the Classroom. *SCHOOL SCIENCE AND MATHEMATICS*. 21: 875-890; 22: 20-32. December, 1921 and January, 1922.

by Pruitt²⁷ in chemistry have resulted in findings resembling those in Table I. For the most part, the results of these studies indicate that so far as imparting information to the students is concerned one method is about as effective as another.

Nearly all of the investigators have based their comparisons upon subject-matter tests and have made little or no attempt to measure other than informational outcomes. Only two men (Dyer and Horton) have made any painstaking and comprehensive attempt to measure some of the other outcomes of science instruction. Dyer²⁸ attempted to determine "the relative value of a developmental-demonstration method and a laboratory method with reference to their efficiency in building up certain outcomes in the minds of pupils and with reference to permanency of realization once established." His study is somewhat unique in the method of approach to the problem and in the outcomes he attempted to measure. For this reason it will be reviewed in considerable detail. He analyzed 35 "professional articles on the objectives of science teaching," published during the period between 1884 and 1922, and representing "the opinions of leaders in the field of education and science." This analysis yielded a list of 49 objectives for a high-school physics course. He then analyzed "into their strengthening and counteracting elements, their completing and limiting elements, and their interconnecting and transfer elements" a list of 7 "outcomes" bearing upon the 49 objectives. These outcomes were as follows: "(1) a scientific attitude; (2) a standard of strength of character; (3) an interest in science; (4) a regard for the common welfare; (5) a realization of the relation of physics to the home; (6) a realization of the relation of physics to commerce and industry; and (7) an attitude of respect for the spirit and service of science."

The study involved 112 high-school physics students divided into two groups of 49 and 63 respectively. These groups were balanced (approximately) by means of an intelligence test and a preliminary test in mechanics. Dyer divided the experimental part of his investigation into three experiments (or trials) which were conducted on three successive days. One fifty-five minute

²⁷ Clarence M. Pruitt. An Experiment on the Relative Efficiency of Methods of Conducting Chemistry Laboratory Work. (Master's thesis, University of Indiana, 1925.) Reported by Francis D. Curtis. *A Second Digest of Investigations in the Teaching of Science*, pp. 289-292.

²⁸ John H. Dyer. An Analysis of Certain Outcomes in the Teaching of Physics in Public High Schools, Doctors Dissertation. University of Pennsylvania, 1927.

period was allotted to each experiment. A rotation method of experimentation was employed. "With one group (Group 1) the laboratory method was used in the first two trials: with the other group (Group 2) the developmental demonstration method was used. In the last trial, however, Group 1 worked under the demonstration method and Group 2 worked under the laboratory method."

A few days before the experiments both groups were given a basal test to determine whether "the realizations tested for later in the investigation were not present at the beginning of the investigation." This test comprised tests requiring discussions, diagrams, and definitions. In each of the three experiments, a final test of ten questions was given during the last ten minutes of each experimental period. These three final tests were composed of questions similar (but not identical) to the questions in the basal test. Eight months later "the same final tests were given again in order to test for the permanency of the realizations once established."

The findings in these experiments indicate that "the developmental-demonstration method is more efficient in establishing realizations in the minds of pupils than is the laboratory method."

"As for the relative permanency of realizations established by the two different methods the evidence is not so definite." In one experiment the results favor the laboratory method; in the other two experiments they favor the demonstration method. However, the differences are so slight in all three experiments that they indicate "at least no marked advantage in favor of either method in regard to permanency of established realization."

Two factors leave Dyer's findings open to question. These factors are: (1) The validity of the final tests was not determined. It was not shown that these tests actually measured the extent to which the desired realizations were established in the minds of the pupils. (2) The reliability of the final tests was not determined. Since there were only ten questions in each test and since the majority of these questions were of the true-false type, it is doubtful whether these tests were accurate measures of the outcomes of the two different methods. However, Dyer is to be commended for his comprehensive efforts to measure outcomes of science instruction other than informational ones.

Horton²⁹ made the most extensive attempt to measure manipulative skills and abilities involved in laboratory work. This part of his study will be reviewed somewhat in detail. In this phase of his investigation, 117 high-school chemistry students from 10 sections were involved in the first experiment; 43 from 2 sections, in the second experiment; and 345 from 11 sections, in the third experiment. In the first and second experiments the groups under comparison were equated on the basis of Regents' scores in biology; in the third experiment, on the basis of scores in the mid-term examination in chemistry. In the first two experiments the demonstration method was compared with the regular individual laboratory method. In the third experiment the comparison included four methods: "(1) individual laboratory work 'without directions,' the so-called 'Problem Method,' (2) individual laboratory work following directions but with these directions consciously generalized, (3) individual laboratory work following directions from a manual—the regular method of previous practice, and (4) demonstration of all experiments by the teacher." The comparisons were based on an individual performance test in the first experiment; on a group performance test in the second. Four different tests were used in the third experiment; (1) a written test of chemical judgment, (2) a test of ability to make apparatus set-ups, (3) a group performance test, (4) an individual performance test.

The evidence in all three of these experiments favored the individual laboratory method; in the third experiment the order of preference of the different methods was the same as the order given in the above descriptions of these methods. However, this superiority in the use and manipulation of laboratory apparatus is of doubtful value. "There appears to be no evidence that these abilities and manipulative skills have any value outside of the field of chemistry." Apparently students who do not pursue the study of chemistry beyond a high-school course will have little use for these manipulative skills and the ability to use chemical apparatus.

Another finding casts further doubt upon the value of this superiority in manipulative skills. Thirty-eight chemistry students, who had been trained for 20 weeks by both the demonstration and individual methods, were given an individual performance test. Thirty-five biology students with no previous

²⁹ Ralph E. Horton. Measurable Outcomes of Individual Laboratory Work in High School Chemistry. Teachers College. *Contributions to Education* No. 303.

training in chemistry watched an instructor go through the operations in this test. They were allowed one practice trial on half of the items and no practice trial on the other half. On the following day they were given the test. The results with the two groups show that "fifty per cent of the pupils examined individually can do 79 per cent of the manipulations after 20 weeks of training. Approximately the same percentage of untrained students succeed in doing 80 per cent of the same manipulations when tested immediately after one practice period." Horton states:

These (32) items (in the test) were a fair sampling of the 55 most important techniques involved in the general course of high school chemistry.

It would be absurd to expect that these manipulative abilities would function as habits from this learning, but there is an indication that the operations themselves are simple; that they involve no manual skill not possessed by the average high school student without training in chemistry; and that the task of learning these operations is not severe.

This evidence seems to justify the conclusion that these manipulative skills can be acquired in a small fraction of the time ordinarily devoted to laboratory work in a high-school chemistry course. If such is the case the superiority in manipulation resulting from the use of the individual laboratory method is of very little value.

The foregoing discussion has emphasized three implications of the results of this investigation: (1) with respect to the outcomes measured by the ordinary written test "no method showed a superiority amounting to certainty." (2) Evidence of the "transfer" of these manipulative abilities and laboratory skills to other situations is lacking. (3) Apparently these manipulative skills can be acquired in a comparatively short time. These implications led the investigator to believe that "the discontinuance of the individual laboratory work and the substitution of demonstration therefor, after a preliminary period of training, appear justified and feasible."

At the college level, comparatively few relevant studies have been made, Bowers³⁰ made a study in elementary chemistry at the Colorado State Teachers College. Two methods of instruction were compared. In one, the students had two periods of recitation and one double period of laboratory work per week; in the other, two periods of recitation and two double periods of laboratory work per week. The study covered a period of ten

³⁰ W. G. Bowers. The Importance of Laboratory Work as Compared with Textbook Work in the Study of Chemistry. *SCHOOL SCIENCE AND MATHEMATICS*, 24: 606-613. June, 1924.

quarters and involved about 192 cases. "Two general examinations, on the work covered by the text and the laboratory exercises, were given each quarter." For the ten-quarter period, the average grades made in these semi-quarterly examinations were 81.2 per cent for the students having one double period of laboratory work per week and 85.7 per cent for those having two double periods of laboratory work per week. This gave a difference of 4.5 per cent in favor of the students having two double laboratory periods per week. Bowers does not state the reliability of this difference. But, since it is based on teachers' marks which are generally unreliable, it is probably not statistically significant.

Hurd³¹ made several studies dealing with laboratory work in science at the University of Minnesota. In one study he compared two plans of studying human anatomy by dissection. With one plan two students worked on a cadaver; with the other four students worked on a cadaver. The study extended over a period of four quarters; ninety-six students were involved. Students were paired and groups were equated on the bases of past ratings in school subjects; scores made on the Miller³² test for graduate students; ratings in the Sigma X reading test;³³ average number of honor points made in required pre-medical subjects, exclusive of languages; marks in animal biology; and ratings in industry.

"All factors of instruction were kept as constant as was feasible, except the matter of the groupings of four's and two's." Achievement was measured by means of extensive objective tests, a "practical examination" in which the students were required to identify 100 dissected specimens, and weekly estimates of each student's work by the laboratory instructor.

The results showed no statistically significant differences in achievement favoring either method. "There is no evidence, except individual opinion to warrant the belief that, under the conditions existing in the Anatomy Department of the University of Minnesota, one cadaver for each two students is more advantageous than one for each four students, as far as the measures of achievement employed could determine."

In another study Hurd compared the relative effectiveness of

³¹ Archer W. Hurd, Problems of Science Teaching at the College Level, Doctor's Dissertation. University of Minnesota. 1929. An abstract of this investigation is given in *Science Education*, 14: 652-655. May, 1930.

³² W. S. Miller, University of Minnesota. Analogies Test for Graduate Students (Unpublished).

³³ University of Minnesota Reading Test.

two methods of teaching human physiology, involving different amounts of laboratory work. With one method the students had five lectures, two quizzes, and seven and a half hours of laboratory work per week; with the other, five lectures, two quizzes, five hours of laboratory work, and two and a half hours of assigned library work per week.

Two equated sections were formed on the bases of scores made on the Miller test for graduate students; ratings in the Sigma X reading test; number of honor points made in freshman subjects; and average number of honor points gained in required premedical subjects.

The study was carried on for one quarter. Results were measured by means of comprehensive objective tests; a term laboratory rating on the laboratory book handed in by the student, judged by the two laboratory instructors coöperating; a final oral rating, which was the mean rating given by any two of the four instructors selected by the student; a final laboratory mark, which was the mean estimate of two tests; a "set-up" and a "tracing"; and the mean of 19 five-minute quizzes given during the quarter.

In describing his findings Hurd states: "There is some evidence to indicate that 7.5 hours of laboratory work in human physiology . . . produces measurable achievement in excess of that produced by 5 hours of laboratory work plus 2.5 hours of library work."

In a third study Hurd attempted to investigate the value of laboratory work in mechanics. He compared a group of architectural students, having three lectures and one quiz per week, with a group of architectural engineering students having three lectures and one quiz per week, and in addition one double-period of laboratory work each week. Ten students majoring in architecture were paired with ten students majoring in architectural engineering on the bases of ratings in mathematics and average honor points.

The study was carried on for a quarter. Achievement was measured by means of three objective tests, having a total of 154 items, the final grade, and a laboratory test which was part of one of the objective tests. The questions in this laboratory test "were devised so that it would be possible for a student to get the necessary information from the text." The results all favored the architectural engineering group. The laboratory test and the objective test, of which it was a part, yielded statis-

tically significant differences in favor of this group. The investigator concludes that "the evidence indicates in general that the architects rate lower in achievement in mechanics and the reason is partly, at least, due to the lack of laboratory work. Two considerations must not be forgotten, however; first, the bases of pairing the students are not of as proven validity as they should be; second, the small number of architects left make the usual statistical treatment inadvisable for drawing conclusion."

Noll³⁴ reports several studies of laboratory instruction in inorganic chemistry carried on at the University of Minnesota. He describes his investigation as "a study having for its primary purpose the evaluation of individual laboratory work in chemistry as a method of instruction. In general the procedure is by one of two methods: (a) to compare two groups receiving instruction which is identical in all respects except for the amounts of laboratory work; (b) to compare two groups whose instruction is identical except that some other method of instruction is substituted for a portion of the laboratory work of one of the groups."

The studies involved 845 students in beginning chemistry classes during the period 1926-29. All of these experiments were carried out in courses which were two quarters in length. This means exclusive of holidays and examination periods, about twenty-two weeks of instruction.

Two highly reliable and valid examinations were devised to measure achievement in inorganic chemistry. "In most cases both examinations were given at the beginning and again at the end of two quarters of instruction so that gains as well as final achievement could be measured. In all experiments the control and experimental groups were matched as individuals on the bases of initial scores in these examinations, percentile ranks in college ability tests and scores on other pretests, such as, the Iowa Placement Examination CA1 Revised for measurement of aptitude in chemistry. The average of about sixteen 50-minute written quizzes and the average of two 2-hour written final examinations were used as additional measures of achievement. In all groups, grades in laboratory work which were based on the laboratory notebooks and the estimates of laboratory assistants were also used as measures of achievement."

³⁴ Victor H. Noll. *Laboratory Instruction in the Field of Inorganic Chemistry*. Doctor's Dissertation. University of Minnesota. 1930. A report of this investigation under the title, "The Optimum Laboratory Emphasis in College Chemistry," is given in *School and Society*, 32: 300-303. August, 1930.

"The most important problem in this study has been the question of the value of individual laboratory work in chemistry. Supplementing this was the problem of finding something that could be substituted for some of the laboratory work without loss to the student. As far as any measures used in this study are concerned, 2 hours of laboratory work out of 5 per week do not seem indispensable. The fact that students can be deprived of these two hours without significant loss would appear to be rather important evidence on this point. As for substitutes for laboratory work, of the two that were tried, recitation or oral quiz seems a fairly profitable substitute, but outside reading does not. It may be that a different plan for the outside reading or a different selection of topics would show results different from those found here."

"The most striking implication of these studies would seem to be that our methods of instruction in college chemistry can undergo considerable change and manipulation without our being able to detect any great effect on the results, at least in the present state of educational measurement."

Payne,³⁵ at Transylvania College, made a thorough attempt to compare the lecture demonstration and individual laboratory methods of instruction in first-year college chemistry. He describes his procedure as follows:

"The data used in comparing the relative merits of class demonstration and individual laboratory instruction in first-year college chemistry were furnished by twelve sections of college general chemistry students. The twelve sections were from six groups of two paired sections each. A total of 299 students in four colleges and taught by five instructors was involved. One section of each group was taught during the first part of the year, generally a semester, by class demonstration with no individual laboratory work during this introductory work, while the paired section was taught throughout the year's work by the more commonly used individual laboratory method. After the introductory period by class demonstration, generally for one semester, this section of students joined the other section in study by the individual laboratory method. The students were paired on the bases of pretests; the Iowa Placement examination, Chemistry Aptitude; a chemistry training test; Powers' General Chemistry Examination; and group intelligence tests.

"The attainment of the paired sections was measured on the ordinary items considered in grading chemistry students. Standard chemistry training tests, the Iowa Placement Examination, Chemistry Training, Powers' General Chemistry Test, and Rich's Chemistry Tests were given at intervals. An attempt was made to devise tests for each group that could be scored as nearly objectively as seemed reasonable."

In conclusion Payne writes: "From a study of the literature

³⁵ V. F. Payne. *The Lecture-Demonstration and Individual Laboratory Methods Compared*. Doctor's Dissertation. University of Kentucky. This digest is made from a report of the investigation in the *Journal of Chemical Education*, 9: 932-939, 1097-1102, 1277-1294. May, June, and July, 1932.

and his own experimental work the writer concludes that the better students will succeed as well, and those students of lesser ability will probably succeed better (as success is ordinarily measured) in their entire first-year's work in college chemistry if they have a period of introduction, approximately one-half year, through teacher demonstration with the exclusion for that period of individual laboratory work."

The writer recently completed a study³⁶ in physics at the University of Minnesota. The purpose of this investigation was to compare groups of students in mechanics who did two hours of laboratory work per week for a period of one quarter with groups who did no laboratory work with respect to three outcomes, viz:

- (1) Knowledge and understanding of the fundamental facts and basic laws of mechanics.
- (2) Development of scientific aptitude.
- (3) Acquisition of manipulative skill and knowledge of laboratory techniques, in so far as these outcomes were reflected in achievement in subsequent laboratory courses in heat and electricity.

The study was made during the years, 1930-34. Most of the experiment was carried on during the spring quarter, 1930 and the fall, winter, and spring quarters, 1930-31. The investigation was prolonged till the end of the winter quarter, 1934 in order to study the effect of laboratory work in mechanics upon achievement in subsequent laboratory courses in physics. The subject matter involved was contained in a one-quarter course in the elements of mechanics offered to beginners in the physics department. Five hundred and ninety-five students, most of whom were freshmen and sophomores, were used as subjects.

In the various comparisons the criteria used for matching individuals and equating groups were college ability, mathematical ability, initial knowledge of subject matter, and scientific aptitude.

In the comparisons with respect to the first outcome, some of the measures of achievement were based upon a scaled objective test of high reliability and validity;³⁷ others were measures

³⁶ Henry W. Duel. *Measurement of Some of the Outcomes of Laboratory Work in College Physics*. Doctor's Dissertation. University of Minnesota. 1936.

³⁷ This test was a C-scale of thirty items. Correlating the scores on the odd-numbered questions with the scores on the even-numbered questions as earned by a group of 340 students, and applying the Spearman-Brown prophecy formula yielded a reliability coefficient of $.88 \pm .01$. Correlation between scores on this test and other measures of achievement of the kind ordinarily used in mechanics ranged from .50 to .91; they averaged .72.

of the type commonly used to determine achievement in mechanics, such as, unscaled objective tests, quiz averages, final examinations, and final averages. In the comparisons with regard to the second outcome, the measure of development was the score gain on the Stanford Scientific Aptitude Test (SAT) over a period of one quarter; in those with respect to the third outcome, the measures of achievement were the final grades in the heat and electricity laboratory courses.

On the basis of the evidence the following conclusions seemed reasonable:

(1) Students in mechanics who do no laboratory work will gain, on the average, as much knowledge and understanding of the fundamental facts and laws of mechanics as those students who do two hours of laboratory work per week for a period of one quarter; there will be very little difference between the two groups with respect to variability in achievement.

(2) The average student in mechanics, over a period of one quarter, will improve a small but statistically reliable amount in scientific aptitude, as this aptitude is measured by the Stanford Scientific Aptitude Test; two hours of laboratory work per week will have no significant effect upon the amount of this improvement.

(3) On the average, students who take the laboratory work in mechanics will not acquire sufficient manipulative skill and knowledge of laboratory techniques to affect noticeably their achievement in subsequent laboratory courses in heat and electricity, as this achievement is measured in this investigation; if they do gain skill in the manipulation of apparatus and a knowledge of laboratory techniques, these manipulative skills and techniques will be of negligible value outside of the mechanics laboratory.

This review of experimental investigations reveals a number of findings which render questionable the present extensive use of the individual laboratory method in the teaching of science.

(1) Individual laboratory work is expensive, both in money and in time.

(2) At the secondary school level, with respect to immediate results, the lecture-demonstration method seems to be superior to the individual laboratory method; with respect to the retention of information and realizations, one method seems to be as effective as the other.

(3) At the college level the evidence indicates: first, that a

considerable amount of laboratory work could be omitted without serious loss to the students; second, that two hours of laboratory work per week will have no significant effect upon scientific aptitude as this aptitude is measured by the Stanford Scientific Aptitude Test; third, that an introduction to a science course through teacher demonstrations is more advantageous to the students than an introduction through individual laboratory work.

(4) With regard to the acquisition of manipulative skills and laboratory techniques the individual laboratory method appears to be superior. This superiority, however, is of doubtful value for two reasons: first, evidence of the transfer of these manipulative skills and laboratory abilities to other situations is lacking; second, students with no previous training in a science can, apparently, acquire necessary skills and techniques in a small fraction of the time ordinarily devoted to a laboratory course in that science.

SECOND NATIONAL CONFERENCE ON EDUCATIONAL BROADCASTING

The Second National Conference on Educational Broadcasting will be held at the Drake Hotel in Chicago, November 29, 30, and December 1, 1937.

The objectives of this Second Conference, as formulated by a committee, are as follows:

- I. To prove a national forum where interests concerned with education by radio can come together to exchange ideas and experiences.
- II. To examine and appraise the situation in American broadcasting as a background for the consideration of its present and future public service.
- III. To examine and appraise the listeners' interest in programs that come under the general classification of public service broadcasting.
- IV. To examine the present and potential resources of education through radio.
- V. To examine and appraise the interest of organized education in broadcasting.
- VI. To bring to a large and influential audience the findings that may become available from studies and researches in the general field of educational broadcasting, particularly such studies and researches as may be conducted by the Federal Radio Education Committee.

The American system of broadcasting, an evaluation of broadcasting from the point of view of the listener, educational broadcasting, and the future of radio have been selected as the topics of the four general sessions. Speeches on these subjects will be made by prominent representatives of education, the radio industry, and the listener, and will be followed by periods of open discussion.

Those who are interested in the maximum contribution of broadcasting to educational and cultural development are invited to participate in the Conference.

THE POINT SYSTEM OF GRADING AS A MEANS OF INCREASING PUPIL PARTICIPATION IN HIGH SCHOOL CHEMISTRY CLASSES*

BY KENNETH E. CONN

Bloomington High School, Bloomington, Ind.

The grades, objectives, methods and subject matter of any course are so closely related and mutually interdependent that it is scarcely possible to undertake the discussion of one factor without involving the other three. It is therefore necessary to devote some time to objectives, methods, subject matter and common errors of teachers and their relation to grading before outlining the nature and character of the Point System.

Work in the field of grades and grading has been associated principally with certain administrative studies concerning the type of grades which shall be issued on report cards to parents and to variance in teachers' grades. According to Belting,¹ marks are used for the following purposes:

1. To determine credits.
2. Scholarships.
3. Exemptions.
4. College entrance recommendations.
5. Inter-scholastic and intra-mural competition.
6. Rewards.
7. Punishments.
8. Eliminations.
9. To make possible administration studies with classes.
10. Teachers have become skilled in the present system.
11. We have always done it this way.

The letter system is probably more widespread in its usage and permits a greater degree of uniformity than other grading systems now in vogue. Starch² recommends that there should be five points in the grading scale: four passing grades and one grade indicating failure. This system is in general use throughout the country. The State of Indiana, State Department of Public Instruction, Bulletin No. 100, pp. 93, recommends and has modified it according to the following scheme:

A—Excellent, 3%–10%
B—Good, 20%–22%
C—Average, 40%–50%

* Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, St. Louis, November, 1936.

¹ Belting—*The Community and Its High School*, D. C. Heath, 1923.

² Starch, Daniel—*Educational Psychology*, Macmillan.

D—Poor, 20%–22%
F—Failure, 3%–10%

It is significant to note that the same reference, p. 91, has the following comment to make: "The letter system, like the percentage system, lacks uniformity. What is A work to one teacher may be B work to another."

There are those who oppose the comparative marking system because of the following reasons:

1. Grades are statistically unreliable and psychologically inadvisable.³
2. Present practice, contrary to newer ideas of psychology, is an obstacle to the most efficient learning. It encourages working for grades rather than real aims.⁴
3. The present system is an injustice to the child.⁴ Grades are inadequate and inaccurate.
4. Teachers cannot interpret one another's grades.⁴
5. Grades dull the edge of intellectual curiosity.⁵
6. If grades are maintained, some children never know success.⁵
7. Marks encourage dishonesty.⁵

Dr. Fowler also advises that instead of a written report card, a descriptive comment on the child as a whole, including social relationships, general habits, interest and effort, health activities, reading, language, literature, spelling, social studies and industrial and fine arts be adopted.

John A. Lund⁶ in advocating the elimination of the comparative marking system proposes in its stead the development of a cumulative record of data that will give the essential characteristics of the pupils' physical, intellectual, emotional and social growth.

Undoubtedly much of the above criticism of the comparative marking system is justified. However, in fairness to teachers, it must be said that one contributing factor to the criticism of teachers' marks, especially variance in teachers' marks, is the wide variation in the nature and meaning of the grades employed throughout the different schools of the country. Administrators should determine the type and character of the grades to be used. A uniform scale of grading should be adopted by the secondary school systems of the country as a whole. Once this is done, the individual teacher will possess a better understanding of marks, of what is wanted, and will be in a much

³ Dawson, Mildred A., "Report Cards without Marks." *Educational Journal*, December, 1936.

⁴ Macomber, F. G., "Marking System Rates an E." *Journal of Education*, Vol. 118, January, 1935.

⁵ Fowler, Burton P., President of Progressive Educational Association: (a) "How Much Do Marks Matter?"—*Parents Magazine*, Vol. VIII—No. I, January, 1933. (b) "Teachers are Told Marks May Harm Pupils." *School Management Magazine*, April, 1936—pp. 208.

⁶ John A. Lund—"A Teacher's Statement." *School Executive Magazine*, February 1936, pp. 229–230.

better position to estimate grades. Unless some such system is adopted, the teachers remain in much the same situation as a group of chemists and physicist scattered throughout the country, each attempting to use an individual thermometer which is different from that of his colleagues, each thermometric scale being based upon what seems to be hot or cold for that particular locality, rather than upon definite standards for the nation as a whole. Picture, for example the United States Weather Bureau attempting to compile data for a weather map using an assemblage of such diverse instruments of measurement and you have some idea of why there is variance in teachers' marks of the same paper. At the present time, the only method of obtaining anything like objectivity is in the use of the standardized test. In the meantime, the alert classroom teacher will keep records which are cumulative enough so that a fair and honest estimation of the pupil's achievement may be made and which may be readily translated into any of the current grading scales, local or otherwise.

The situation is to be compared to that in the field of business. Achievement of the general objectives of education, together with the broad general aims of the chemistry course, is our stock in trade. Grades may be compared to money as the medium of exchange. Similar to money, a certain amount of evil will always accompany the use of grades. Since the parent is within his rights in requesting information concerning the progress of his child, and the child must be rewarded with some estimation of his achievement in the course, it is quite likely that we will continue to use grades, regardless of how the scale may be modified. It is therefore our duty as teachers to reduce to a minimum the evils accompanying the use of grades.

The average teacher, like the overworked proprietor of a small grocery store, is tired at the close of day, reluctant to balance the books, and inclined to put off this important phase of the work until later. Like the successful business, this phase of the work cannot be neglected. Each six weeks and at the end of the semester, we must strike a trial balance and issue six weeks and semester grades. The student must feel that he has actually earned the grade assigned to him. We must see to it that he is satisfied with the reward of his toil, content that the grade represents his actual accomplishment, and convinced that his work in the course has been definitely worthwhile. Teachers cannot afford to be satisfied with a meagre sampling of the

pupil's work. The sampling must be general enough to include all items essential for a cumulative record. Otherwise, they are compelled to resort to guesswork in the issuance of the six weeks' and the final grade.

Throughout this discussion we shall assume that the general objectives of education are: *Health, Vocation, Leisure, Social*, and that the principal objectives of the high school chemistry course are:

1. Exploration and guidance.
2. The development of a scientific attitude on the part of the student, including the ability to reason along chemical lines, and to apply what has been learned to new and similar situations of a chemical nature.
3. To impart an appreciation of the importance of chemistry in the home, in industry, agriculture, and other broad national interests.
4. The acquisition of a certain amount of culture, in that the student becomes well informed upon matters of chemical interest and is able to read the work of this science as well as to discuss such matters intelligently.

It is a well known axiom that people learn things by doing them. Theoretically, in the well conducted recitation, the students both ask and answer the majority of the questions. The teacher acts as chairman of the meeting, interrupting infrequently, generally when advice is requested by the class, or to secure continuity of the topics under discussion. From the viewpoint of learning, a teaching procedure will provide for maximum participation on the part of the pupils. The grade of the pupils will reflect an estimate of the value of this participation. Since the personnel of the class includes a considerable range in individual differences, opportunities for participation must be wide and varied enough to offer enrichment for every member of the class, with the possible exception of the lower quartile. Each student should accept the responsibility of participating in the discussion and other activities of the class. At the close of the hour he should leave the class with the definite realization that he has contributed something constructive to the progress of the work undertaken that day. The enrichment program should be designed for and should definitely stimulate the members of the A and B groups. In so far as it is possible, students undertaking activities of an enrichment nature should be allowed to select those activities in which they engage. They should not feel that they are compelled to do this work, or it will become burdensome to them. Credit should be given for the quantity of the work as well as its quality. The grading pro-

gram should be flexible enough to include the wide and varied interests of the class.

Many teachers, in their efforts to emphasize subject matter, have a tendency to stress the first objective, Exploration and Guidance, and practically ignore the other three. This is unwise from the viewpoint of future society. It is not possible for all of the students to become chemists, nor is it fair to the class as a whole to expect that. Assuming that each of the objectives is of nearly equal importance, the final grade should be a composite measure of the pupil's achievement in all four of the objectives. For example, those who wish to become chemists or enter into the allied vocations, should stress activities dealing with the first and second objectives, i.e. Exploration and Guidance and The Development of a Scientific Attitude, particularly where minimum essentials of laboratory and theory are concerned. On the other hand, those who wish to become lawyers should not be slighted because of their preference. It is our duty to teach the child, not the subject. If the student is somewhat clumsy in the manipulation of apparatus, a rather poor experimenter, provision may be made to stress the third and fourth objectives, Appreciation and Culture. This may be done by offering work in the way of outside readings, individual and group projects, special reports to the class dealing with health, sanitation, local industries of chemical interest, etc. Those interested in mathematics should be allowed to undertake the solution of numerous and diverse mathematical problems of a chemical nature. In each case where special work is done, full credit must be allowed, otherwise the worker will feel cheated and discouraged to undertake further work of this nature.

At the present time too much emphasis is placed upon the value of written records. Too much attention is given to the examination. Many teachers rely almost entirely for their estimate of laboratory work upon the grade assigned to the written reports of laboratory experiments. This is probably a false premise. In some cases students become so anxious that they write up of the experiment be entirely correct that they work to that end and do not stress the actual performance of the experiment. In other cases, wilful cheating results. In estimating the value of laboratory work, some attention should be given to laboratory technique, i.e. the manner in which the student conducts the experiment, his initiative, skill in assembling apparatus, ability to solve minor problems concerned with the experiment,

etc. Why rely upon an inanimate laboratory record, when the instrument of this record, the student and his experiment, lie right before our eyes during the laboratory hour? The probable solution is to grade the animate as well as the inanimate. It is good pedagogy to inform the class that their laboratory grade is determined by two factors: (1) the write up of the experiment and (2) laboratory technique.

The laboratory is essentially a place of supervised study. In the light of what has already been said, many teachers fail to include this in the grading plan. Some teachers have a mistaken idea of supervised instruction. Apparently they conclude that the primary purpose is a sort of conference in which the students quizz the teacher in regard to certain assigned exercises, questions and problems. The students act as secretaries and record whatever answers they are able to glean from the teacher. The teacher does the work, the pupils merely copy the results of what has been said. Obviously some instructions, demonstrations and explanations are necessary by the teacher to clarify the work. However, participation by the teacher should cease here. The principle of learning by doing should be invoked. The teacher should not monopolize the entire hour, a fair share of the time should be devoted to study by the pupils, and ideal study conditions should be maintained. It is well for the teacher to take at least ten minutes from every eighty minute laboratory period to observe and grade the individual members of the class. The students should understand that they are being graded and that they are to call on the teacher only in case of emergency. Such a procedure will have a tonic effect upon the entire class and will do much to eliminate certain disciplinary problems such as cheating, playing, loafing, etc. During the supervised study hour, the teacher should also sample and grade certain specimens of the students' work.

Every effort should be made to correlate the work of the laboratory with that of the recitation. Preferably, the work of the laboratory should precede that of the recitation, the text being used for reference and enrichment mainly.

Some teachers pursue the policy of taking up the write up of the laboratory experiment as soon as the performance of the experiment has been completed. To prevent copying, they refuse to allow the laboratory manual to be removed from the laboratory room. Probably a better procedure is for the teacher to stamp the date on the laboratory sheet at the beginning of the hour

to mark the point where the student began the work, and to again stamp the date at the end of the hour to mark the point where the student was working at the end of the hour. It is understood that no further work may be performed or recorded until the next laboratory day. In case the student does work beyond the final marking, no credit for the experiment should be allowed. This plan has several advantages:

- (a) It insures that the work of the experiment has actually been done under the supervision of the instructor.
- (b) It conserves the time of both the instructor and the class. Mechanical details of taking up incomplete experiments, storing laboratory manuals, and handing out such work the next laboratory day are eliminated.
- (c) If the class has been so conducted that the experimental work has preceded the recitation by one to three days, the experiment may be made the basis of the following recitation. The questioning should parallel but not repeat verbatim the questions on the experiment sheet. Some time should be allotted to discussion of assigned readings in the text and elsewhere. Special reports of optional experiments, projects, etc. may also be given at this time. In this way direct correlation of laboratory work and recitation may be obtained.
- (d) If the discussion is conducted in the above manner, the student should be required after the recitation to revise and correct the original notes concerning the experiment. The revised write up of the experiment may then be taken up and graded. The teacher may grade this latter work by the method of sampling two or three of the more important items of the write up and should penalize heavily any errors encountered.

On the whole there is too much participation on the part of the instructor and too little participation on the part of the pupil. The demonstration of spectacular experiments may be over-worked and over-done. Too frequent use of such experiments may lead to a sort of vaudeville atmosphere, the students taking the attitude that they come to be amused rather than to learn. Repeated demonstration on the part of the instructor contributes to a sort of inferiority complex on the part of the class; to the idea, consciously or unconsciously, that such work is beyond the level of their ability. The instructor in some cases becomes a sort of superman in their eyes; one whose feats are to be observed and pondered upon with awe, yet never to be emulated. In other cases, continuous use of the demonstration method leads to complete indifference and intellectual stagnation on the part of some members of the class. Yet there are those who advocate the elimination of all individual laboratory work in favor of the demonstration. Granted that the demonstration method is all that its proponents claim for it, and that the in-

structor is a skilled technician, master of his subject, a splendid teacher, one who from the viewpoint of scholarship can present the work with far greater effectiveness than as though the work were to be done by the pupils, and that there is a saving of time and expense—there are several factors which they overlook:

- (1) It requires considerable skill to command the attention of the entire class for forty minutes day after day.
- (2) Pupil participation is at a minimum. The student feels that he has contributed far less than where individual laboratory work has been offered. In reality he has contributed far less. Hence there is far less interest in the course.
- (3) Assuming that as much subject matter may be taught by the demonstration method as by the individual laboratory method, it still fails to offer an effective program for exploration and guidance. Because it fails to provide opportunity for initiative and self-expression on the part of the pupil, most of the program for the development of a scientific attitude is sacrificed. Students learn to talk glibly in "parrot like" fashion about what the instructor has done and what others have done but their own experiences are barren. When such students are placed in the laboratory on their own resources they are nearly helpless. There is reason to believe that this same helplessness would prevail when confronted with situations related to chemistry in daily life.
- (4) The instructor loses a valuable opportunity for becoming acquainted with the individual differences of the class.
- (5) The instructor uses time in assembling apparatus and conducting the experiment which should be devoted to teaching the class. Usually he does not conduct the work on the level of pupil terms and pupil abilities. Too often his diction is too technical and "over the heads" of the pupils.

This does not argue that the demonstration method is to be entirely eliminated from the teaching program. It does imply that the major portion of the laboratory work should be done by students and that the demonstration method should be used mainly for the following types of work: (a) the teaching of desirable skills and techniques, (b) the preparation and study of obnoxious gases, (c) experiments in which there is an element of danger to the student, however slight.

Adequate provision should be made for necessary absence from school and for the reteaching of fundamentals. The procedure here varies from those who require no make up work and grade according to the outcome of certain tests, to those who require complete repetition of all work missed during absence. Treatment of reteaching shows almost as much variance. The most equitable solution of the problem of make up work lies not in the complete repetition of the work but in a thorough review of the minimum essentials of what was missed by those who were absent. If the subject matter missed was not part of the

minimum essentials, the student should have the privilege of substituting other work in the form of outside readings, problems, special reports, etc. for it. Reteaching should also be concerned principally with minimum essentials and be limited to those who fail to achieve mastery of the fundamentals. The progress and interest of the A and B groups should not be hampered by compelling them to repeat this work along with the lower quartiles. Such work should be individual in nature. Once it is made individual, delinquencies will no longer be popular among borderline pupils, they will be confined to those cases that cannot be avoided. Both the method and the grading system should be flexible enough to promote make up work and reteaching on this basis.

In the development of far reaching facts, laws and theories, too much attention is paid to the development of the conclusion and too little attention to its application. Briefly stated there are about six steps in the learning process:

- (a) Sensing and formulating the problem.
- (b) Measuring and assembling of all the related data.
- (c) Sifting and sorting the data with the view of arriving at a possible explanation of the problem.
- (d) Development of the conclusion.
- (e) Testing of the validity of the conclusion.
- (f) Further application of the conclusion until its use becomes automatic.

It is upon steps (e) and (f) that teachers most frequently fail. Too often they are content to arrive at the conclusion and let it go at that. Sometimes application is omitted entirely. Like mechanical tools, a hammer for instance, the conclusion is of no value to the student unless he uses it. Hence, he soon forgets it. Teachers should not feel indignant if items thus treated show up missing on an examination. They have only themselves to blame.

In connection with the above error, a few instructors seem to place the emphasis upon the problem, and slight the remainder of the six steps. Some instructors require the student to refer to the original statement of the problem and rewrite it. Such a procedure is not conducive to the development of initiative and self-reliance on the part of the pupil. It is suggestive that he may not know what he is doing, belittles his intelligence in general and tends to destroy self confidence during the performance of the experiment. It is doubtful if such a procedure enforces familiarity with the objectives of the experiment.

Members of the A and B groups are familiar with them anyway and it is to be assumed that if the memory of the remainder of the class is of such short duration, the mere writing of the objective will not help much. Members of the D and F groups simply go through the mechanical process of looking up and recopying the author's statement. A lesson in penmanship might be more valuable. A much better way is to check on this matter during the succeeding classroom discussion of the experiment and to grade accordingly.

It is possible to waste considerable class time in the purely mechanical features of drill. The teaching program should provide self-testing and self-teaching devices, which, in addition to drill, offer opportunity for introspection and self-analysis on the part of the pupil. Why waste valuable class time for this purpose when it is possible to get the student to review and drill independently of the teacher? A flexible grading program will provide for enforcement of work of this nature.

There are three levels which pupils attain as the course in laboratory instruction progresses throughout the year.⁷ These are:

- (a) The student acquires skill in the use of the objective materials of the laboratory.
- (b) The student begins to solve problems by the laboratory method.
- (c) The pupils gain the power and spirit of independent research.

While only a few of the students may attain the third level and some may never pass beyond the first level, some attention should be given to these matters, especially in the grading of laboratory technique.

It is the purpose of this article to describe a cumulative system of grading which takes some of the above factors into account. A system which has been subject to some revisions during its development and which admittedly has not reached the state of perfection which the author would like to claim for it. The system has been in use during a period of five semesters in the Chemistry Department of Bloomington Indiana High School. It has been found to work very satisfactorily in the author's classes and seems to merit the consideration of chemistry teachers, if for no other reason than to invite advice and criticism. A brief explanation of the point system follows.

⁷ J. O. Frank, *The Teaching of High School Chemistry*. J. O. Frank and Sons, Oshkosh, Wis., 1932, pp. 115-118.

BRIEF EXPLANATION OF THE POINT SYSTEM

The grades A, B, C, D, and F are given a numerical ranking of 4, 3, 2, 1, and 0 respectively. It is assumed that the essential difference between the Grade A and B lies in the amount of work done. The various factors: laboratory technique, write up of experiments, oral recitation, self-administering tests, assigned exercises, etc. participated in by the entire class are graded on the basis of a four point scale of 0 to 3. Unit tests, six weeks tests, and semester examinations are graded on the basis of 0 to 4.

All grading is a matter of sampling. Each student is sampled daily upon at least one and sometimes two of the above items. The sampling during any one unit is broad enough to include all of the above factors. The instructor reserves the right to make the choice concerning which of the required work is sampled. Unit tests, six weeks tests, and semester tests are required and are weighted so that they count 25% of the total points for the unit, six weeks and semester grades, respectively. Unit, six weeks and semester grades are estimated on the basis of the total points earned from the items sampled. In order to maintain a passing grade, it is necessary for the student to earn from one to two points daily. All six weeks and semester grades are estimated according to the following scale:

Grade	Six Weeks	Semester Examination	Total Points for Semester
D	60	60	240
C	120	120	480
B	180	180	720
A	240	240	960

At the beginning of each six weeks period, the student is asked to write his name on a sheet of paper together with the grade that he feels he is capable of earning and intends to earn and give it to the instructor so that both will know what his objectives are. At approximately the middle of each six weeks period the student is notified concerning the total number of points he has earned during that time. If for any reason he is dissatisfied, provided that he has done passing work, he may acquire sufficient points to reach the next higher rank by any of the following methods:

- (1) By doing optional experiments of his own selection, with the approval of the instructor. (1-3 points each)
- (2) Projects, honor exercises, reports before the class. (1-5 points each, depending upon the quality and extent of the work)
- (3) Pupil demonstrations before the class. (1-3 points each)
- (4) Outside Readings. (One point for every five pages read and outlined. The student is required to give the title of the book, author, topic reported, page references, and the approximate time that he worked. The instructor reserves the right to give him an oral or a written examination over what he has read.)
- (5) Credit is allowed the student for the writing of brief abstracts of items of chemical interest which he has read in the local newspapers, *Literary Digest*, *Scientific American* and other periodicals. Such work being subject to an examination.
- (6) Mathematical problems of a chemical nature. (Credit is determined at the time the work is undertaken)
- (7) Setting up of apparatus and preparing special solutions for the instructor. (Credit determined after the work is completed)

Some idea of the merits of the Point System described herein may be obtained from the following criteria:

- (1) There has been a marked increase in the percentage of students earning A, B, and C grades and a definite decline in those making D and F grades. For example, those making A grades have increased from 3% to 9%. Failures have declined from 7% to 2%.
- (2) The students approve of the system. Results taken by questionnaire and by personal interview from 103 students show that:
 - (a) Eighty-three favor the system because:
 - It gives them a definite share in the determination of their grades.
 - It is fair.
 - It enabled them to stress items in which they were most interested.
 - The grades seemed to mean something.
 - (b) Eleven were satisfied with the system but had no comment to make.
 - (c) Five were dissatisfied with the system because it made them work too hard.
 - (d) Three did not favor the system but gave no reasons for this view.
 - (e) One student did not favor it on the grounds that it made the rest of the class work too hard.
- (3) Comparison with records of previous years shows that pupil participation has increased more than 100%.
- (4) The records kept of 100 activities engaged in by individual students show that in 91 cases participation was voluntary. The teacher made no request for such participation.

Some reasons why the author is favorably impressed with the Point System are:

- (1) It tends to develop initiative on the part of students.
- (2) Promotes activity on the part of the class.
- (3) Creates a friendly attitude of rivalry among students.
- (4) The students assume the responsibility for doing most of the work.
- (5) It motivates the class.
- (6) It provides better recognition for individual differences in the class.
- (7) It keeps the entire class busy.
- (8) It stimulates thought on the part of the individual.
- (9) It makes possible a more complete realization of all the general objectives of the course.
- (10) A higher standard of scholarship is maintained.

CINNAMON

Cinnamon trees once grew in what is now Texas, millions of years ago, when there were dinosaurs to browse on their leaves. A group of fossils which includes leaves of plants like cinnamon, sassafras, sarsaparilla, and maple, found near Stephenville, Texas, are described by Prof. O. M. Ball of the Agricultural and Mechanical College of Texas in the *Journal of Geology*. The fossils represent one of the oldest, if not the oldest, groups of higher plants thus far discovered in America. Their geologic age is given as Lower Cretaceous.

CINCINNATI NATURE RECREATION

BY WILLIAM GOULD VINAL

Nature Specialist, National Recreation Association

Pork packing can evolve from days of feeding hogs on acorn mash. Auto industries can grow out of carriage manufacturing from upland hickory. Builders supplies may be sorted out of glacial gravel hills. Paved roads may be made from alluvial clays. It takes sticky silt and pulverized shale to make the potters wheel go round. Buildings can rise from quarried limestone. Place these industries on the Ohio River cross roads, with Mill Creek Valley from the north and the Licking Valley from the south, and you can picture Cincinnati arising. When natural resources are great enough, it is then that you can count on the arts.

Nature has been kind to Cincinnati. That may be one reason why *Nature Recreation* is its oldest culture. It dates back to the days when Cincinnati had family physicians. Dr. Goforth spent his leisure time digging mastodon bones at Big-bone Lick, Kentucky, and raised ginseng as a hobby. Dr. Daniel Drake claimed the forest as his school, nature as his teacher, and squirrels as his classmates. Perhaps these men were puttering with their antiquities when John James Audubon walked in and became the first curator of the oldest Museum of Natural History west of the Alleghenies. Since then, Cincinnati has justified itself as a place of culture in music, art, government, and parks. Longfellow, America's poet laureate, recognized this when he crowned it the "Queen City of the West."

Then came days of Museum contentment. Dust gathered on the bones housed in the Museum's firetrap on Broadway below Fourth Street. The public no longer came to view the musty jars in the biological morgue. The days of the species hunter and civic pride in counting the number of fossils were no more. The Museum must either fold up or turn over a new leaf. The year 1935 marked the beginning of a new era in a new home under the leadership of Ralph Dury. He had more than passing interest, for his father, Dr. Charles Dury had been associated with the Museum for sixty years. Docent trips, nature games, nature hikes, and story hours serviced 65,000 people the first year. The light was turned on, so to speak, and Cincinnatians were given a new lease about life instead of about specimens.

Perhaps old man depression and the leisure time, more than anything else, can be credited for Cincinnati's "back to nature" movement. The Park Department, the School Board, and the Recreation Commission are feverishly at work over this nature question. When history is written this will be known as the period of *Cincinnati's Nature Renaissance*.

The first artisan-naturalists to live between the Miamis were the Mound Builders. In the hills by the California Water Works they had places of worship. At Fort Ancient is preserved North America's largest aboriginal fortress. It is about four miles in length. The 100,000 artifacts removed show that these people carved imitations of animals, such as toads and the now extinct paraquet, on their stone pipes. Archaeologists estimate that there were 30,000 people at Fort Ancient and possibly 5,000 at Mariemont. The evidence is that Mound Builders enjoyed a higher culture than the Indians. It is of more than passing interest that their leisure time was devoted to art and nature.

Then for several centuries there were no people to disturb the stillness of the forest. Large trees grew upon the mounds. Stone implements, baskets, and pottery remained untouched. There were no pilgrimages to worship. Then came the Indians. For a century and a half (1650-1800) the Shawnees grew maize on the flood plain of the Little Miami. They plied the "Big River" in canoes. They too were "children of nature."

The Revolution was over, and in 1788 Colonel John Cleves Symmes and Captain Benjamin Stites (1747-1804) came with colonists from the east. When the armed forces dissolved in 1783, the United States officers who had been comrades for eight years, formed the society of Cincinnati. In 1790, Arthur St. Clair, Governor of the Northwest Territory, called the place Cincinnati, in honor of the Society of Cincinnati.

In the party was one John Filson, a Kentucky school master, who bought 1,500 acres from Squire Boone (1783) and not only wrote the first *Life of Daniel Boone*, but the first *History of Kentucky* (1784). Filson was a surveyor for Colonel Symmes, but mysteriously disappeared in 1788.

The principal surveyor was to run an E-W line between the Miami Rivers sufficiently north to avoid the bends in the Ohio. He was to place a stake at each mile. The assistant surveyors were to run meridians and plant stakes every mile for section corners. The plans were orderly, but resulted in scarcely two sections of the same shape.

The enterprising colonists, observing the extensive "turkey bottoms," made their first settlement one mile below the mouth of the Little Miami. They noticed that nature produced abundantly. Pioneer hunters, like Boone and Kenton, thought that the wild life of the meadow and the fish of the stream would last forever. "Mad Anthony" Wayne swept the country of Indians, but the forests were still in the way of agriculture. For the next hundred years the forests were cleared for tilling the soil, and then agriculture gave way to manufacturing, until today only deep ravines and rugged bluffs support trees.

The story of the naturalists of Cincinnati commences with the biography of Dr. Daniel Drake (1785-1852),¹ who spent the greater part of his life in this city. Born in Plainfield, he left New Jersey before there were any settlers at Cincinnati. His father, a poor illiterate farmer, settled at Mayslick, Kentucky. At first they lived in a sheep shed, but later had a log cabin. Daniel had scant formal schooling as the land had to be cleared, the corn hoed and the cattle fed.

Out of his own initiative, Daniel observed that buds grow larger in the winter. Ten years later this fact interested him in a poem in Darwin's "Botanic Garden." "To my cow boy labors, when twelve or thirteen years of age . . . I ascribe, in part, my admiration of that poem . . . with axes on our shoulders, father and I were often seen driving the cattle before us to the nearest woods,—and when the first tree fell the browsing commenced. As the slippery elm was soft and mucilaginous, twigs of considerable size were eaten . . . but the time required for browsing was not always devoted to work, for the tracks of coons had attractions."

When Dr. Drake was sixty, he wrote about "some of the autumnal lessons, taught in the great school-house of the woods . . . What I contend for is, that to be in the midst of such scenes in childhood and youth, is beneficial. I insist that autumn has its lessons for the mind, its influence on the young heart, and that to many they are most precious." Dr. Drake not only championed the cause of nature study, but that of compulsory education, and as early as 1836 he read a "Report on the Study of Anatomy and Physiology, as a branch of Common School Education."²

¹ Mansfield, Edward, "Memoirs of the Life and Services of Daniel Drake." Cincinnati, 1855. Applegate & Co.

² Drake, Daniel—"Rambles of a Naturalist," 1833.

Young Daniel also had home nature lessons in the form of making butter, cheese, and soap; carding and spinning wool; dyeing cloth with black walnut and butternut dye; and one time he went with his father to barter a two horse load of hay for a bushel of salt. He thus had both a poetical and a practical love of nature.

At the age of fifteen, young Drake went to Cincinnati to be an apprentice to Dr. Goforth. Goforth carried a gold headed cane and powdered his hair as did his contemporary, Dr. Waterhouse of Boston. When cowpox was received from England, Drake was the first person west of the Alleghenies to be vaccinated. Doctor Goforth also gave him the first medical diploma to be awarded west of the Alleghenies (1805). Drake then studied under Dr. Benjamin Rush (1745-1813) a signer of the Declaration of Independence, and popular teacher at the University of Pennsylvania Medical School, and Dr. Caspar Wistar, (1761-1818) after whom Thomas Nuttall had named Wistaria (1818).

Doctor Drake rode in a gig. He would often stop to pick up botanical specimens or fossils which resulted in his writings. His pamphlet *Notices of Cincinnati, its Topography, Climate, and Diseases* (1810), contains chapters on flora and fauna. This later became his more complete work, "The Picture of Cincinnati" (1815) in which he lists 99 species of plants which are alphabetically arranged. (By 1879 there were 1,493 species listed.) He is the first writer to call attention to the drift in southern Ohio, and especially in Cincinnati. The book also contains researches from 1807-1815 on prehistoric mounds, medicinal plants, and systematic observations on the climate. He was both accurate in his observations, complete in his investigations, and interesting in his style. The book was of such value that it was translated for the use of European scientists. His chief work was on *Diseases of Interior Valley of North America* (1830), which also included topography and meteorology. He founded the Ohio Medical College (1819) where he served four different times, amid jealousies and wrangling.

William Holmes McGuffey (1800-1873)³ was born in Washington County, Pennsylvania, and came to Youngstown when the Connecticut Western Reserve was opened (1802). The house in which he was born was restored by Henry Ford and

³ Minnich, Harvey C., "William Holmes McGuffey and his Readers," American Book Company, 1936.

removed to Greenfield Village. William "chored" his expenses at Greensburg Academy. His first reader was written at Oxford, Ohio (1825) where he was Professor of Ancient Languages in Miami University. Up to this time rural Ohio was bookless. Daniel Boone's spelling and dialect was the language of the commoner as late as 1850. McGuffey's Readers contained classical stories of "The Lame Dog," "Twinkle, Twinkle" and "Mary's Lamb." Exemplary stories were related about pets, ferocious beasts, the air, sea and land. Reverent attitudes toward God and elders were stressed. Humane education was taught by kind deeds toward animals, in which stories about dogs and cats were most abundant. The stories of dogs as the boy's friend, dogs who rescued people, and dogs who exhibited faithfulness, were full of moral advice. The McGuffey books were in reality nature readers and as such shaped the democratic mid-western mind up to the 1920's.

His brother, Alexander H. McGuffey was the author of the Fifth and Sixth Readers, and of McGuffey's Speller. He married Elizabeth Drake, the daughter of Daniel Drake.

The "College of Teachers" (1833-1843) was one of the first important teachers' associations in America. It was organized to unite the teachers with the learned men of the time. Among those who spoke or wrote for it were Dr. Daniel Drake, the family physician, William H. McGuffey, then president of the University of Cincinnati, Dr. Lyman Beecher (who arrived in Cincinnati in 1832), and Professor Stowe. The meetings were highly cultural and gave a great impetus to authorship, which made Cincinnati the intellectual capital of the west and resulted in many publishing houses centering at this city.

John James Audubon, the first to paint birds in a natural background, came to Cincinnati (1810) to secure subscriptions for his work. "The well-to-do class in Cincinnati must be a very thoughtful people; so many whom I solicit for subscriptions tell me that they will think about it." Audubon met Dr. Daniel Drake, who in 1818 had interested a group in collecting for a museum. In 1819 Audubon was offered the position of taxidermist, which he held for six months. It was opened to the public in 1820 as the Western Museum. The Cincinnati Directory (1819) notes that "decent strangers will be cheerfully admitted if they apply to any member." Dr. Drake was the first secretary. When Audubon came back in 1829 he wrote "At Cincinnati I visited the Museum . . . It scarcely improves since

my last view of it, except indeed by wax figures and other shows as are best suitable to make money, and least so as to inform the mind."⁴

In April, 1878 the Cincinnati Society of Natural History started to publish a quarterly journal, deciding "that all descriptions of new species shall receive proper illustration." This was considered important for absolute identity. There were curators of fourteen different departments, including mathematics and astronomy, ichthyology, comparative anatomy, conchology, meteorology, etc. It will be of interest if a few typical notes are quoted from the heyday of the society's monthly meetings.

September 3, 1878, F. W. Langdon read a paper on the "Revised List of Cincinnati Birds (256 species), 4 new members elected. Professor Stone made a verbal report on the late solar eclipse. Donations were received of a collection of fossils and minerals, quartz crystals, birds eggs, and eight beetles.

December 3, 1878, 2 new members. Paper by E. O. Ulrich, on "Reclassification of fossil corals" and Mr. James F. James "A Catalogue of plants, ferns, and fungi of the vicinity of Cincinnati."

At a special meeting January 23, 1879 it was "Resolved, that a Committee of ten, who take special interest in the study of the lower Silurian Rocks of Southwestern Ohio, etc. be appointed, by the chair, to report to this Society upon what seems to them to be the correct nomenclature of these rocks."

The energies of the society were not limited to what people today would call dry facts. The necessity for conservation was beginning to be felt. Langdon, in his paper on Cincinnati birds,⁵ reported seven species that had disappeared within forty years, namely the wild turkey, prairie chicken, paraquet, swallow-tailed kite, two largest woodpeckers, and the raven. He goes on to say that to offset these losses we have the cowbird and some others omitted from Dr. Kirkland's list. "Within the present decade two European species, the house sparrow, and the skylark, have also been added to our fauna, the former of which seems likely to exceed in numbers any one of our native species, unless its extraordinary increase should be checked by natural or artificial means, a consummation devoutly to be wished." The skylark evidently did not succeed in establishing itself, and as early as 1878 ornithologists regarded the introduction of the English sparrow a mistake. Langdon refers the reader

⁴ Gillespie, Dorothy, "Ornithology Leaflet #2, Cincinnati society of Natural History, February 26. 1937.

⁵ Cincinnati Society Natural History, *Quarterly Journal*, Vol. 1, 1878.

to an able paper on the subject by Dr. Elliott Coues, in the *American Naturalist* for August 1878.

At the meeting of May 2, 1882, John W. Shorten read a paper concerning the "Relation of Rapacious birds to Agriculture."⁶ It appears that the County Commissioners were acting on the popular notion regarding hawks and owls subsisting on song and game birds and poultry and advertised a per capita for hawks' scalps. Investigation shows "that instead of being detrimental to agricultural pursuits, they are positively beneficial." Shorten read letters to support this conclusion from Spencer F. Baird and Elliott Coues. He could not know that over fifty years afterwards the Ohio Legislature would again disregard all scientific evidence in this respect. It was about the same time as Shorten's paper that Davis L. James told the society that "Indeed, to us, laws protecting ferns and wild plants seem as reasonable and as necessary as those protecting game."⁷ These were forerunners of the Audubon Society of Ohio of Cincinnati, and the Wild Flower Society of Cincinnati which have done such yeoman service in Conservation education.

The opportunity to search the early volumes of the quarterly Journal of the Cincinnati Society of Natural History is a rare privilege. In the archives of the Society, which can boast of 70,000 books and pamphlets, are hidden biographical notes relative to the early naturalists of what was for a long time the scientific center of the west. That the museum was rated high may be seen from the fact that Dr. E. D. Cope left his second, or duplicate collection of shells, to the Cincinnati Museum. The membership list of the Society of Natural History was a social register.

Robert Buchanan (1797-1879) for over twenty years president of Cincinnati College, was a life member. In 1843 he purchased a country estate at Clifton where he introduced landscape gardening by using choice fruits and flowers for the setting. That year the Cincinnati Horticultural Society was organized at his house. For over thirty years he was president of Spring Grove Cemetery, and, living near it, he was able to give an early impetus to its well deserved reputation for beauty through plants.⁸

George Graham (1798-1881) came to Cincinnati in 1822.

⁶ Cincinnati Society Natural History, *Quarterly Journal*, Vol. V, No. 2, pp. 67-70.

⁷ Cincinnati Society Natural History, *Quarterly Journal*, Vol. III, No. 4, 1881.

⁸ Cincinnati Society Natural History, *Quarterly Journal*, Vol. III, No. 2, July, 1880, pp. 74-78.

His father contracted to build the first turnpike over the Allegheny Mountains (1816). Graham was one time president of the Western Academy of Natural Sciences and delivered the welcoming address when Marquis de Lafayette visited the city in 1825.⁹

Charles Dury (1847-1931), another life member and president, ran a taxidermist shop for some forty years. He counted among his friends Alfred Russell Wallace, E. D. Cope, Baird, Le Conte, Ridgway, and Coves. He made a very complete collection of beetles. Colonel L. E. Bryant, who presented the Museum with his collection of 14,000 specimens of Indian artifacts of the Ohio region, began his work as a hobby when he was a boy.

As early as 1874, the Cuvier Club was organized for the protection of fish and game. Seven years later this effort in conservation was followed by a visit of Baron Richard Von Steuben, Royal Chief Forester of the German Empire. As a result of his brief stay, the Ohio State Forestry Association was formed at Cincinnati. Warren Higley, president of the Ohio State Forestry Association, in speaking of John A. Warder (1812-1883) wrote that he was a veritable student of nature, and his love among men was as lovingly beautiful as it was among his plants and trees. . . . He is justly called the "Father of American Forestry." Dr. John A. Warder came to Cincinnati in 1857. He was president of the Natural History Society (1870-1875). In early life he knew Audubon, Michaux, Nuttall, and Bartram. It is said that he influenced not only the Natural History Society, but the Horticultural Society, the Astronomical Society, and the public schools. He was a public spirited man, who taught nature through ability and love.

V. T. Chambers (1830-1885) believed with Cicero that "the study of nature is the true food of the human understanding." In making his presidential address before the Society of Natural History he did not claim so "pretentious a title as that of scientist."¹⁰ He goes on to say that "An address upon an occasion like this, to a mixed audience of scientists, and of people who make no pretensions of science, ought to be of a general and semi-popular character, so as to afford something of interest

⁹ Cincinnati Society Natural History, *Quarterly Journal*, Vol. IV, No. 1, April, 1881, pp. 85-90.

¹⁰ Cincinnati Society Natural History, *Quarterly Journal*, Vol. II, No. 2, July, 1879, pp. 71-92.

to all. But the question in the present instance is not what such an address *ought* to be, but what under the circumstances it must be. . . . I have accordingly made choice of the subject of "The Metamorphoses of insects as illustrated in the Tineid Genus. *Lithocolletis* of Feller." Chambers did not claim to be a scientist, yet he was a profound student of microscopic lepidoptera. His type species of *Tineina* were placed in the Museum of Comparative Zoology at Cambridge.

Cincinnati has been rated as a fine fossil collecting ground. Over 800 specimens have been described from the locality, notably by V. P. James, E. O. Ulrich, and Charles B. Dyer (1806-1883). As a boy, Dyer was fond of hunting, but early laid aside the gun for the geologist's hammer. His collections, weighing over a ton, were sold to Agassiz (1880). Nine fossil specimens were named for him.¹¹ Cincinnati's large fossil collections went to Cambridge. Rich friends were absent even in those days. It would be a pity if the Museum should dissolve because of the lack of loyal supporters.

The annual report of the Director, Ralph Dury, for the fiscal year ending December 31, 1936 says that "the indifference of the public school authorities toward nature study in the schools, in past years, seems to be passing." Mentioning that the Museum depends on membership Mr. Dury is probably correct in believing that no museum of natural history in this country is doing as effective work on so small a budget. The Junior Society of High School Boys (1928) holds biweekly meetings, publishes pamphlets, and goes on collecting trips. Their publications include a paper on "The Black Widow Spider," and a "Guide to the Butterflies of Cincinnati." The Cincinnati Museum has done much for Cincinnati. Benefactors have arisen on all sides to support other cultures. Cincinnati should now rally to support its oldest cultural organization, the Society of Natural History. The Baker-Hunt Foundation Museum (1930) across the Ohio River at Covington erected by Mrs. Margaretta W. Hunt at a cost of \$30,000 to house the Archie J. Williams collection, is an example of what some loyal citizen of Cincinnati should do before a notable collection and a free public service is scattered to the wind.

In referring to Covington, Kentucky, mention should be made of the notable Beard family who once lived there. James

¹¹ Cincinnati Society Natural History, *Quarterly Journal*, Vol. VI, Oct., 1883, pp. 207-210.

Carter Beard (1837-1913) was born in Cincinnati. He was the brother of Daniel Carter Beard, who says that "when James got his sheepskin for an attorney and counselor-at-law, handing it to his father he said 'I did this for you. I am now going into art for myself.' " And he became well known as a writer of illustrated articles on plant and animal life, contributing to *Harpers*, *Saint Nicholas*, and *Outing*. His father, James Henry Beard (1812-1893) was an artist who painted domestic animals, and his uncle William H. Beard (1824-1900) was fond of painting wild animals who acted like human beings. Dan Beard is well known in the scout world as "Uncle Dan," and is popular with them for his boys' handy books on camp lore and bugs. Covington boys today are having an unusual opportunity to follow their bent in the nature hobby shop of Archie Williams, which is located in the basement of the Baker-Hunt Museum. It is the best nature workshop that the writer has ever seen.

The Governor, by proclamation, set aside April 27, 1884, as the first Arbor Day in Ohio. John B. Peaslee, Superintendent of Schools, prepared a pamphlet entitled "Trees and Tree Planting." The local schools were dismissed to enable the pupils and teachers to take part in the celebration of tree planting in Eden Park. Here, the first memorial groves in America were planted to the presidents, to the pioneers, and to the authors. Dr. Randall J. Condon, who came to Cincinnati as Superintendent of schools in about 1912, was also a champion for nature study. Then there was a depression in nature study in the elementary grades. At present Dr. Leon D. Peaslee, principal of Hartwell school, and a nephew of Superintendent Peaslee, is Chairman of a curriculum committee on Nature Study.

At the Cincinnati High Schools there is an unusual opportunity to show America the way in nature recreation. Areas comprising as many as thirty acres of natural woodlands, such as surround Western Hills High School, and Walnut Hills High School, have been purchased by the Board of Education. As this land is contiguous to the parks and parkways of the Cincinnati Board of Park Commissioners, these high schools have outdoor school-room facilities that are unparalleled.

Recreation centers for the entire community—that they belong to all ages instead of a favored few is also revolutionary. One can picture public school forests where erosion control is carried on instead of being a matter of lip service—where manual training classes build cabins for the Youth Hostel Move-

ment instead of necktie racks, and where physical education will be more than dumbbells and ball batting. Nature trails and hiking trails; bird houses, feeding stations and winter shelters; wild flower and fern gardens; outdoor classrooms; theatres and picnic areas; tree nurseries, sugar orchards, and evergreen stands will be the activities which educators will come from far and near to see how each is carried on. They will look in amazement at these large areas that Cincinnati leaders visualized while they at home were still thinking of small hard-surfaced school yards of less than an acre. Today the public schools have 101 leaders in physical education, 83 in art, 32 in music, and none in outdoor nature study. Tomorrow, if Cincinnati educators catch up with the school ground visualizers, these areas will be building human beings and not institutions or athletes.

If the elementary schools have been dilatory in the matter of nature education the park department has been progressive. The oldest park is Garfield, which was presented to the city in 1817. The oldest purchased park is Washington, which was acquired in 1855. The largest public park within the city is the Mount Airy Forest (1911) of 1,304 acres. Its flat topped hills and deep wooded ravines consist of nearly a million planted trees, the first of which were planted in pure stands. The Civilian Conservation Corp has built check dams, and more recently has built a Forest Lodge for community use. One frequently sees the statement that Mt. Airy is the first municipal forest in the United States. Massachusetts specifically authorized the establishment of municipal forests in 1882, New Jersey in 1906, and Pennsylvania in 1909. Rochester, New York started a forest in 1909. In 1914 Fitchburg also claimed the distinction of establishing the first municipal forest. It would appear that the final honor may depend on the definitions of the terms forest and preserve. As Ilion, Johnstown, Salamanca, and other New York communities had municipal forests in 1910 the best that Cincinnati can say is that it was among the first. Even that is worth boasting about.

In 1930, Irwin M. Krohn, president of the Park Board, instigated the equipping of a trailside museum and nature trail in Burnet Woods, a wild flower trail at Alms Park, what might be called a bird trail at Mt. Echo, and a geology trail at Ault Park. The movement at once became popular and today requires a full time park naturalist, Hester Stephenson. An at-

tractive 30 page booklet schedules 48 activities for 1937. The 24 nature walks, 13 star gazing trips, and 11 bird hikes ought to appease the nature hunger of the community.

Another evidence of park vision and foresight are the "look-out" stations where people come up out of the "Basin" to contemplate. It seems as though Cincinnati were built upon seven hills and that six of them were captured for parks and playgrounds. Alms Park is typical of one of these overlook spots. From it one may see the Kentucky Hills, the glimmering Ohio River, and the thousand acre Lunken Airport. The Krohn Conservatory (1933) in Eden Park is also a monument to Park achievements.

The Board of County Park Commissioners was appointed July 17, 1930. The first park, Sharon Woods (1932) consists of 667 acres. It is a wilderness area as compared with the highly developed city park. Cincinnati, like most large communities, is beginning to think in metropolitan and county terms.

The Public Recreation Commission (1927) is one of the youngest civic bodies but is not lacking in vigor and progressiveness. Cincinnati had been generous with parks and schools and cultural offerings, but the basin district still had congestion and delinquency. There was a shortage of play and recreation areas where they were needed most. The Commission leased twelve acres for what is known as the C & O Playfield. Donations amounting to \$8,000.00 were received. Ramshackle tenements and abandoned cellar holes have been replaced by a level stretch of ground having fertile top soil. Here a flower garden, bordered with Mexican fire plant, forms a beautiful oasis in a district which formerly represented one-fortieth of the city's population with thirty-fortieths of the city's crime and of deaths from social diseases and tuberculosis. These people left their hoes as Cincinnati of old left his plow to help save the empire. They were brought in during the World War, but unlike the simple mannered Roman, they cannot return to their southern cabins. Fortunately, a garden is being brought to them. These dozen acres represent the most significant area of any municipal playground. If sunflowers, morning glories, and hollyhocks can make life more pleasant and more abundant for the neighborhood they will produce a good that cannot be estimated in dollars and cents. To bring about this emancipation will require skilled leadership and the mind of a Lincoln.

Through the coöperation of the Commission and the Natural History Museum, a branch museum has been established at the C & O Playground in a portable school building. This work is under the direction of B. F. Lee, a graduate in biology from Indiana State University. This is the first branch museum in Cincinnati. A case of minerals and crystals suddenly thrust on a people has no meaning. His work went better when the folks of the neighborhood collected and arranged their own materials. He is faced with the biological principle that one enjoys those things most which come through his own efforts. A museum workshop is more meaningful than a museum storehouse. Mr. Lee has a capacity for solving the difficulty.

The Recreation Commission more recently has established a department of Nature Recreation (1937) under the direction of Robert Strauss. Through the efforts of the Commission the Cindoky Field Naturalist Club was organized this year to arrange weekly trips afield under the leadership of competent naturalists. The first trip was to the sugar orchard of Charles Baker, just off the Three C Highway at Zoar. The Commission plans to have a day camp, nature trails, and naturalists. The movement will be coördinated with the nature work of the schools and the park board. It is also recognized that adult recreation will demand more attention to nature interest activities. It is planned to leave the ravines in a wild state for growing things—for trees, wild flowers, and birds, where people may seek quietness, beauty, rest, and relaxation. Cincinnati's promontories give the feeling of expansiveness and Cincinnati's ravines give the illusion of wildness and remoteness. The citizens should be grateful that the authorities are not determined to put all the streams in sewers nor possessed with the idea that all hills and valleys should be leveled.

Whatever Cincinnati considers worth while, she goes after in an effective way. This is illustrated by no better example than the new Union Terminal (1933), built at a cost of forty-one million dollars. A railroad station usually looks like the back door to a city. In Cincinnati it has all the requisites of the front door. It is more than a railroad terminal. It is a work of art and science, and no story of the nature recreation of Cincinnati is complete that omits the Union Terminal.

Winold Reiss, the artist, was born in Germany and comes of generations of painters in the Black Forest. As a child he painted Indians, and he is familiar to us as the painter of Black-

foot Indians, which appear on calendars. Mr. Reiss used real life figures as models, beginning with Chief Okie, and ending with the steel workers on the terminal. His two friezes, "Transportation" and "Commerce" represent the story of the Ohio River with its landscape and its development. It is a pageant of Cincinnati History from the first log cabin to the sky line of the present city. Commencing with the prairie schooner of the pioneer, it portrays the wood burning locomotive and the raft and river steamer each in its turn.

Pierre Bourdells, who was responsible for the mural decorations, from early days was associated with learned men in the studio of his sculptor father, among whom was Rodin. In the moving picture theatre he has given glimpses of modern inventions—the airplane, zeppelin, and phonograph. In the lunch room one may see fish, game, and fruits. The private dining rooms have ceiling decorations of aquatic animals and flowers. The restaurant alcove has linoleum carved in low relief, which shows monkeys, black panthers, and the gazelles of French Africa.

Nature recreation in Cincinnati commenced with the nature-art of the mound-builders, and ends with the nature murals of the steel builders. Nature and art in Cincinnati have always gone hand in hand. Repeatedly, it is a city of culture. And, as we close the story as it reads today, it is entirely proper to leave the reader at the railroad station. The next chapter in Cincinnati's nature recreation will have to be written in a large way to keep pace with its record of the past.

FOREST FIRE

Airplanes may be giving directions to forest fire fighters on the ground the next time the fire devastates a large wooded area.

Rangers at Stanislaus National Forest have been testing the practicability of giving instructions to ground crews from the air.

During the past few weeks a plane has been flying over lookout stations in the Forest, making announcements through a loudspeaker system every time it passed one. Rangers have been reporting on the audibility of the signals, which have been broadcast from different heights and under different wind conditions. CCC enrollees at a camp in Calaveras State Park, near Big Trees, reported they heard "Hello, Calaveras, Big Trees, hello!" perfectly.

TEACHING THE SUBTRACTION OF SIGNED NUMBERS

BY M. W. TATE

Gooding, Idaho

Teaching the subtraction of signed numbers is undoubtedly the hardest task that confronts the teacher of elementary algebra. Neither arithmetic nor out of school experience provides a background for algebraic subtraction, and the student, already aware of the fact that arithmetic subtraction is included in algebraic addition, sees neither reason nor need for further subtraction. Thus the teacher encounters difficulty from the very start.

The writer is convinced that several of the conventional methods of teaching this important unit are inadequate, if not real barriers to the development of quantitative thinking. Consider the bank—asset—liability method of showing $-3 - (-4)$ equals $+1$. The teacher may know that subtracting a debt will free the asset held against it at the bank, that if a debt greater than a second debt is subtracted an asset will be freed large enough to pay the second and leave a balance in black, but the words and situations necessary to the presentation of this notion will all but obscure the purpose. After the debt question is settled the teacher will find she has yet to teach the subtraction of signed numbers. Again, to teach a class the maneuvering necessary to finding differences on the number scale is seen by none but the very brightest to be related to finding differences between ordinary numbers. The technique involved simply smothers the objective. Austrain addition, though convincing, makes no attempt to rationalize the process, and finds its best use in checking the answers obtained in the practice of a more direct method. Fortunately for these methods there is the subtraction rule; and, with it, even the dullards can mutter their way through the rest of the course.

It is the purpose of this paper to present a different method of teaching the subtraction of signed numbers—one which goes immediately to the subject of subtracting numbers. The method is somewhat arbitrary—as any method of teaching a unit which has no counterpart in arithmetic must be—but the reader will agree that it parallels the two phases of pupil experience with subtraction: namely, of having something left when a smaller quantity is subtracted from a larger, and of having a deficit—

of being in the "hole"—when a larger quantity is subtracted from a smaller.

Let us assume the pupil has mastered the addition of signed numbers, and that he appreciates the fact that negative numbers for practical purposes are numbers less than zero, and positive numbers, numbers greater than zero, and that he has a good understanding of the words "minuend," "subtrahend," and "remainder," or "difference." As a preliminary lesson he is given 24 pairs of numbers involving all possible combinations of signs and is directed to underline the larger in each pair; and to state the difference, counting through zero and disregarding sign, between the numbers in each pair.

The subtraction work is begun with the series of numbers—

Series I

$$\begin{array}{r|rrrr} 4 & 4 & 4 & 4 & 4 \\ \hline 4 & 3 & 2 & 1 & 0 \end{array} \quad \begin{array}{r|rrrr} 4 & 4 & 4 & 4 \\ \hline -1 & -2 & -3 & -4 \end{array}$$

The class will of course agree on the correct answers to the exercises on the left of the vertical lines, and these answers are written on the board and checked with the check used throughout: Subtrahend plus Remainder equals Minuend. Before attempting the examples on the right the students are questioned concerning the effect on the remainder of decreasing the subtrahend unit by unit while the minuend remains the same. When the class agrees that the remainder under such conditions is increased unit by unit, the examples on the right are considered. Skillful and patient questioning will insure that any student can come to the board and write the correct answers to these examples. After the answers have been slowly and carefully checked, the question is raised concerning the nature or sign of the remainder when the subtrahend is less than the minuend—the reasonable result of subtracting a smaller quantity from a larger. When the class agrees that it is positive, the statement, "When the subtrahend is less than the minuend, the remainder is positive," is written on the board and saved for subsequent reference.

Now a new series is begun, after making sure the class agrees to the fact that any quantity subtracted from itself leaves zero. The series is—

Series II

$$\begin{array}{r|rrrrr} -4 & -4 & -4 & -4 & -4 \\ \hline -4 & -5 & -6 & -7 & -8 \end{array}$$

After the left hand examp'le is worked, the class is again questioned about the effect of decreasing the subtrahend unit by unit when the minuend remains the same; and after most of the class agrees on the answers, and the necessary checking is done, individual work is begun. The rest of the class period is devoted to working simple exercises of the types found in Series I and II. If difficulty is met, say for example, in subtracting -9 from -6 , a new series of numbers like Series II but beginning with $-6 - (-6)$ is worked out. The assignment will, of course, consist in numerous easy exercises in which the minuend is the greater.

In presenting the subtraction combinations in which the subtrahend is the greater, the following number series are used—

Series I

$$\begin{array}{r|rrrr} 4 & 4 & 4 & 4 & 4 \\ 0 & 1 & 2 & 3 & 4 \end{array}$$

Series II

$$\begin{array}{r|rrrr} -4 & -4 & -4 & -4 & -4 \\ -4 & -3 & -2 & -1 & 0 \end{array}$$

In crossing the vertical lines from left to right in Series I, the idea of decreasing the remainder by increasing the subtrahend is established and the principle "When the subtrahend is greater than the minuend, the remainder is negative" is developed and copied on the board. Finally, the subtraction in Series II is rationalized with the two notions (1) any number subtracted from itself leaves zero, and (2) increasing the subtrahend decreases the remainder.

In summary: the method described above results in treating subtraction as a two step process:

1. Finding the absolute difference between the numbers.
2. Determining the sign of that difference by the reasonable principles that, (a) when a smaller quantity is subtracted from a larger there is a favorable balance, a positive remainder and (b) when a larger quantity is subtracted from a smaller there is a deficit, a negative remainder.

When every pupil understands, or believes he understands, the "Why" in the subtraction of signed numbers, the usual rule, as a time saver may be given.

*When you change address be sure to notify Business Manager
W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.*

SOME CONSIDERATIONS REGARDING SCIENCE AND EDUCATION

BY OTIS W. CALDWELL

*General Secretary, American Association for
the Advancement of Science*

It is my purpose to discuss three points which relate to the educational ends toward which science teaching may be directed.

I. *The expectations which we hold for the educational uses of science* are varied and not always clearly defined. All of us hope to see the study of science produce more and *better results in the lives of those who engage in science studies*. Accompanying this hoped-for quantitative and qualitative improvement, we desire to see an *increase in the numbers of persons who benefit* through science. Then, following those improvements, we expect a marked effect upon science itself through the *growth of worthwhile knowledge*.

Historically, science teaching seems to have placed these three expectations in the reverse order from my statement of them. Indeed, it is a fair question whether educators have recognized all three expectations. Too often science has been taught in order that there may be more scientists, hence greater growth in science knowledge, whereas making more scientists is an incidental by-product of good science teaching. It has been urged that more people should study science, whereas more people *will* study science when the well-supported conviction becomes widespread that science study is highly useful in its direct and indirect help to people. Mere urging that all people shall study science does not seem to have been very effective. It must be that there is not a wide-spread opinion that science study is essential to life improvement. Can it be that science teaching has not been directed toward life improvement? Would it be wise to urge more definite and more extensive specific requirements that all young people must study more science? Such a requirement would be unwise until our science instruction has proved that its services are good for all young people. Thus, our *Expectations* must be focused through the efforts to have science teaching produce more and better results in people's lives. The second as well as the third expectation therefore becomes an accessory to the first, and the first

has been strangely neglected. As an illustration, science teaching has dealt too largely with fundamental principles of the dynamo, and too little with the human uses of the electric light and driving energy coming from the dynamo. The number of people who must properly use and be protected against light and driving energy is far greater than those who must build and operate dynamos. Please observe that we do not overlook the importance of study of the dynamo. It is a topic for intensive and prolonged study by a few, not by all those who use light and power.

II. My second-point relates to the *intellectual aspects of science*. This is a far more complex problem than superficially suggested by the illustration used above. In the past, we have said that the intellectual disciplines of science are of chief importance. Are we about to say now that intellectual aspects are not important? Did we formerly say that facts, principles and generalizations about dynamos make up the science that should be taught on this topic? And shall we now say that the uses and controls of electric currents in men's affairs should make up the science taught on this topic? Shall we now omit facts and principles, and teach and test upon uses and controls? Do we believe that careful and dependable thinking is one function, and that effective living is an unrelated function? The answer to this question is very important to the future relations of science and education.

Some of us believe that rigorous and highly accurate intellectual consideration of special scientific matters, when undertaken with any but superior and scientifically inclined students, is doomed to failure. Experience has proved this. There was an earlier advocacy of this kind of science for all, namely in the report of the Committee of Ten. What science subject one studied was said to be unimportant, provided the way of studying it was like that indicated above. Schools and colleges then required this kind of science. There are persons and institutions with whom such ideas still prevail. My opinion is that this point of view and the eminence of the men and institutions advocating it, has been a major obstacle in the development of science education. We are mostly agreed, I believe, in the opinion I have just stated. Indeed, we should hardly need devote much attention to this idea were it not for two stubborn facts; first, that some influential scientists and institutions still retain the idea, and second, that other narrow and exclusive

guiding criteria now indicate the danger of making similar mistakes. If a restricted list of principles and generalizations should become the dominating feature of scientific instruction, it cannot be long until former errors and disappointing results will reappear. The fact that a new terminology is used to clothe the objectives will not largely affect the outcomes.

We need to be quite clear that we must not omit rigorous and accurate thinking about science. Nor shall we omit facts, generalizations and principles. These are but the essential means to the chief concern, namely the kinds of science which will produce the best results in the lives of people. Generalizations and principles are not the main objectives, but are the transportation devices by which the journey is made toward the objectives. And the journey is not taken unless the waystations, the intermediate objectives principles and generalizations, are so sensed that they are meaningful in terms of human problems of scientific nature.

III. My third point relates to *Science education and the growth of science knowledge*. From childhood to old age, a true learner is always asking questions and trying to secure valid answers to them. The child's questions are usually simple and the answers are often known by his associates, are recorded in printed form, also usually may be discovered or demonstrated through simple observation and experiment. Then, if there is well-organized and coherent science education, any individual who has had a continuous program of science education reaches his adult years, not with the feeling that his education has been completed, but that there is an increasing significance of the questions he asks of nature. Should there not be a recognizable steady advance in the kinds of problems science is asked to answer? Do not these problems steadily find their answers less and less in the form of teacher, text and documentary statements, and more and more through data one may gather from nature's sources? That is, should science in its uses in education steadily develop the tendency toward finding and interpreting data that were not previously recorded and interpreted?

The particular vocation one has chosen and his particular uses of his leisure hours will largely determine the fields in which his unsolved problems will be found. One may be a patent lawyer who plays golf when he has free time. One of his clients asks for a patent to cover a new electrical device. In studying the case the lawyer canvasses electrical energy, its applications

in other devices, and defines new problems one of which his client claims to have met. He probably reaches the conclusion that, notwithstanding the existence of thousands of electrical devices, more problems await solution than have yet been solved. In his golf, as a thoughtful golfer, he notes the need for a golf ball which is phosphorescent, or otherwise self-illuminating, so that approaching darkness, autumn leaves, or failing eyesight, may not reduce his score. Or, as he travels the golf course and notes the coloring autumn leaves, he asks his biological friend about the cause of autumn coloration. In reply he gets a long discourse upon researches upon autumn coloration which discourse ends with the statement that some of the problems that are involved are not yet answered.

Similar illustrations might be given because what is known and what is not known are constantly presenting themselves to those who think. What is not known, when clearly defined, is the beginning of added knowledge. Not all such definitions of the unknown are followed by new knowledge, but many are. The point is, however, that education is in need of the kinds of science instruction which results in recognizing and using what is known, in defining what is not known, and in desiring and seeking new knowledge about things so defined.

These points which I have briefly discussed are:

The expectations which we hold for the uses of science in education are that science shall produce better results in the lives of people, an increase in the number of those who benefit through science education, and added growth in worthwhile science knowledge.

The intellectual aspects of science education, which formerly were dominant, must not be lost in our present day objectives.

If science is most usefully taught, its way of working continues from childhood to adult life, and results in constant additions to science knowledge.

UNCLE SAM'S BOOKSHOP

65,500 valuable publications are available at low prices from the Superintendent of Documents, Washington, D. C. Separate price lists in the various fields are supplied free, such as: Education, Foods and Cooking, Geography and Explorations, Birds and Wild Animals, Insects, Forestry, Plants, Maps, and many others. Teachers and libraries should make extensive use of this excellent source of valuable educational material that may be obtained at very low cost.

TOOTH DECAY: ITS CAUSE AND PREVENTION

BY EDWARD C. COLIN

Wilson Junior College, Chicago, Ill.

Intensive study always leads to the conclusion that the state of an organism at any moment is the resultant of a complexity of factors. Tooth decay in man offers one of the best examples imaginable of the interaction of the three primary factors: (1) Heredity; (2) External Environment; and (3) Activities of the Individual.

Specialists tell us that about 95% of all Americans develop tooth decay by the time they are adults—and this in spite of all our tooth brushes and dentists. Among certain primitive peoples, on the other hand, undecayed teeth are known to be the rule. For example, Stefansson,¹ who spent years studying the Eskimos, says of these people that those who do not eat "civilized food" to any extent invariably have undecayed teeth, although the teeth are sometimes badly worn down by the sand in the food. At the end of his second expedition Stefansson brought back 106 Eskimo skulls and in not one was there found evidence of tooth decay, except where the decay followed the breaking of a tooth through accident. This certainly suggests diet as an important factor in tooth decay. And as everyone knows, the diet of the primitive Eskimo is largely meat.

Goldstein,² in more recent and extensive studies, confirms Stefansson's findings. In 800 jawbones of the prehistoric Eskimos he found 6.5% with defective lower molars (the teeth usually attacked first by decay). Most of the decayed spots were no larger than pin heads. Collins³ found from examination of the teeth of 296 living Eskimos, 26% with tooth decay. Those still living as hunters and fishermen in remote regions showed very little tooth decay as compared with those living near white settlements. At Nome he found more than half the natives with decayed teeth. The amount of dental decay was directly proportional to the extent with which the Eskimos supplemented their native sea food diet with the food of the white man.

Still more recently Price,³ in a survey of 600 Seminole Indians in Florida, has shown that those who live in the cypress swamps of the Everglades on their old time diet have almost

¹ Vilhjalmur Stefansson, *The Friendly Arctic*, 1924.

² *Science Supplement*, Vol. 75, No. 1943, Mar. 25, 1932.

³ *Science Supplement*, Vol. 81, No. 2099, Mar. 22, 1935.

perfect teeth, while those who have left their native homes and live on the fringes of civilization have "an atrocious amount of dental decay."

In general it seems that the grain eating tribes among the American Indians, such as the Pueblos of the Southwestern States, have considerable tooth decay, while the meat eating tribes are relatively free from it.

Why is diet so important a factor in tooth decay? Most workers now recognize that the immediate cause of tooth decay is the growth of certain acid producing bacteria, such as *Bacillus acidophilus*, in the mouth; the acid causes a breakdown of the enamel with the subsequent invasion of the dentine by a variety of microorganisms. The food of the bacteria consists primarily of carbohydrates, especially sugar.

Bunting⁴ and Jay⁵ report striking results in reduction of tooth decay in children as a result apparently of a severe limitation of sugar in the diet. According to Jay the lowest incidence of tooth decay ever reported in this country occurs in an orphanage in Ann Arbor, Michigan, where over 85% of the children fail to develop tooth decay from year to year as compared with 50% in the public schools. In this institution there is a pediatrician who is a "crank on sugar." Sugar is not served at the table. The children get no candy and only rarely ice cream. Apples eaten raw are the chief form of dessert. About half the calories in the diet come from bread and potatoes. The diet is below standard in calcium and phosphorus and in vitamins C and D. Nevertheless, the children are said to be very healthy, although undersized and underweight. In this connection it is interesting to note that Stefansson found sugar peculiarly distasteful to the Eskimos of Victoria Island, and even children of four and five objected violently to the taste of sugar, candy, sweet preserves, canned fruit, etc. Eskimo infants, however, took to sugar as readily as infants among white people.

The retention of carbohydrate food debris in contact with the teeth obviously favors the growth of bacteria, and hence predisposes to tooth decay. Here the activities of the individual in wielding the tooth brush may become a factor. The relative effectiveness of the tooth brush in preventing tooth decay is still debated; its importance has probably been overestimated in the past.

⁴ *Science*, Vol. 78, pp. 419-421, Nov. 10, 1933.

⁵ *Illinois Health Messenger*, Vol. 9, No. 6, pp. 40-44, Mar. 15, 1937.

But proper diet plus clean teeth are not the whole story, for at this point the factor of heredity enters. According to Hanke,⁶ who made extensive studies of the teeth of children at a large children's home, Mooseheart, Illinois, there is a definite tendency toward the development of tooth decay, which is nil or low in some cases and high in others. Just why some children are highly susceptible and others insusceptible when living on the same diet is, according to Hanke, not known. He found no significant differences in total calcium and acid-soluble phosphate content of the blood serum. Hanke stresses the importance of large doses of citrus fruit juices (supposedly on account of the vitamin C) added to an otherwise normal diet, in arresting dental decay; but in a certain percentage of the cases this was not effective.

Jay is of the opinion that the basis of hereditary immunity to tooth decay is the immunity to *Bacillus acidophilus*. He finds that individuals who reach maturity without dental decay are free from these bacteria, and he has been unable to infect them experimentally by feeding massive cultures of *Bacillus acidophilus*. As an experiment in the Michigan orphanage referred to Jay gave the children in some of the cottages all the the candy they wanted. Most of them had previously been negative for *B. acidophilus* and free from tooth decay. In the course of a few days on the candy diet most of the children became positive for *B. acidophilus* for the first time. The high sugar diet was not continued to see whether tooth decay ensued. Although it is not proved that natural immunity to tooth decay is always associated with immunity to acid producing bacteria, the correlation is certainly an interesting one.

One factor which we might expect to be important but which seems not to be so is the structure of the enamel itself. Teeth with imperfectly formed enamel (hypoplasia) such as occurs in rickets seem no more susceptible to tooth decay than normal teeth. Hanke, after a special study of twenty children with obvious hypoplasia found such teeth decayed no more readily than normal appearing teeth. Jay comes to the same conclusion; he mentions enamel so soft that it can be scraped with an ordinary steel instrument, which still did not decay.

It is of course a common observation that tooth decay prefers certain points of attack, such as pits and fissures in the grinding surface of molars, the junction of the teeth and gums,

⁶ Milton T. Hanke, *Diet and Dental Health*, 1934.

and the regions between the teeth. These are just the spots where food residue is most likely to be retained in contact with the enamel. And any peculiarity in the conformation of the teeth (either hereditary or environmental) tending to favor such retention should be listed as a factor.

CONCLUSIONS

This brief survey of the factors responsible for tooth decay may be summarized as follows:

(1) The immediate cause of tooth decay is the growth of acid forming bacteria in the mouth.

(2) These bacteria grow readily only in the presence of carbohydrate food debris, especially sugar.

(3) Unclean teeth favor the growth of bacteria of tooth decay by furnishing a rich culture medium for such bacteria. Ordinary brushing operations are not fully effective in removing such debris and for this reason susceptible individuals living on the usual diet of civilized man will develop tooth decay in spite of the use of the tooth brush.

(4) A small percentage of people are naturally immune to tooth decay, perhaps because of their immunity to the bacteria of tooth decay; such individuals do not develop tooth decay on ordinary diets even though the teeth are not kept clean, and even though the enamel may be imperfectly developed.

MATHEMATICAL MAGIC

BY CECIL B. READ

Municipal University of Wichita, Wichita, Kansas

A very good catch question, which is rarely answered properly, is, "What is the largest number which can be written with two figures?" 99 is not the correct answer, for the ninth power of nine, written 9^9 is very, very much larger.

A rather common game, played by two people, is as follows: The first person names some number not greater than nine; the second may then add to that some number not greater than nine; the first now adds to this sum some number not greater than nine; and so on. The first person to reach 100 wins. A little thought will show that if one person names 90, no matter what the other names, the first will win. It is extremely obvious that the important numbers are the multiples of ten. By varying the game, as by allowing no number larger than seven to be named, a different series of key numbers is obtained; slight study will show these to be 92, 84, 76, 68, 60, 52, 44, 36, 28, 20, 12, 4.

ANNUAL MEETING
EASTERN ASSOCIATION OF PHYSICS TEACHERS

in conjunction with

THE PHYSICS CLUB OF NEW YORK

One Hundred Thirty-Sixth Meeting

THE CONNECTICUT COLLEGE FOR WOMEN

New London, Conn.

Saturday, May 1, 1937

- 11:30 Meeting of the Executive Committee.
- 11:35 Business Meeting.
 - Annual Report of the Secretary.
 - Annual Report of the Treasurer.
 - Report of the Committee on Current Events.
 - Report of the Committee on Magazine Literature and New Books.
 - Report of the Nominating Committee.
 - Election of Officers.
- 12:15 Opening of joint Session.
- 12:20 Introductory Remarks. Mr. Samuel B. Yacknowitz, President of The Physics Club of New York.
- 12:30 Address of Welcome.
- 12:45 Luncheon.
- 1:45 Address: Submarine Escape.
 - Lt. (J. G.) George A. Sharp, U. S. N.
- 2:45 Visit to The United States Coast Guard Academy.
- 4:45 Visit to the New London Submarine Base of The United States Navy.

**OFFICERS OF THE EASTERN ASSOCIATION OF
PHYSICS TEACHERS**

President, RALPH H. HOUSER, Roxbury Latin School, West Roxbury Mass.

Vice-President, JOHN P. BRENNAN, High School, Somerville, Mass.

Secretary, CARL W. STAPLES, High School, Chelsea, Mass.

Treasurer, PRESTON W. SMITH, 208 Harvard St., Dorchester, Mass.

BUSINESS MEETING

Annual Report of the Secretary

The three regular meetings this year have been held as follows:

The 134th at Wellesley College, Dec. 12, 1936.

The 135th at Rindge Technical School, Cambridge, Mass. March 27, 1937.

The 136th at the Connecticut College for Women, New London, May 1, 1937.

At the 135th meeting we met with the Conference with Teachers of Science at the Harvard Graduate School of Education and at the 136th meeting with the Physics Club of New York.

The meetings have been very well attended which is evidence of the high character of the programs which have been presented.

During the year the committee on College Entrance Requirements formulated a syllabus which was presented to all the members for suggestions and was adopted at the 135th meeting for recommendation to the College Entrance Examination Board.

Our membership today is 145, consisting of 114 active members, 29 associate members and 2 honorary members.

Respectfully submitted,

WILLIAM W. OBEAR, *Secretary*

Treasurer's Report 1936-1937

Balance from previous year..... \$340.46

Receipts: Sch. Sci.

Dues 1934-35 Assoc.....	\$ 1.00	
1935-36 Act.....	6.00	2.00
Assoc.....	2.00	1.00
1936-37 Act.....	97.00	192.00
Assoc.....	29.00	28.00
1937-38 Assoc.....	1.00	1.00

	\$136.00	\$224.00	\$360.00
--	----------	----------	----------

Interest.....		\$ 3.43	\$363.43
---------------	--	---------	----------

\$703.89

Expenditures:

Printing & stationery.....	\$25.25	
Postage & clerical expenses		
Secretary.....	35.16	
Treasurer.....	24.81	
Salary of secretary.....	50.00	
Expenses of meetings.....	12.00	\$147.22

School Science.....	\$223.00	\$370.22
---------------------	----------	----------

Balance forward..... \$333.67

ASSETS

Arlington National Bank (checking acct.).....	\$213.02
Charlestown Five Cents Savings Bank.....	120.65

\$333.67

PRESTON W. SMITH, *Treasurer*

The nominating committee, Mr. Fred Miller, Mr. Homer LeSourd and Mr. Louis Wendelstein presented the following candidates and they were elected to serve for the ensuing year.

President: RALPH H. HOUSER, Roxbury Latin School.

Vice-President: JOHN P. BRENNAN, Somerville High School.

Secretary: CARL W. STAPLES, Chelsea High School.

Treasurer: PRESTON W. SMITH, 208 Harvard St., Dorchester.

Executive Committee: JOHN C. GRAY, Phillips Andover Academy, LAWRENCE A. HOWARD, East Boston High School, and CHARLES S. LEWIS, Brighton High School.

Mr. LeSourd reported for the College Entrance Requirements Committee that the syllabus which we approved at the 135th meeting had been sent to the College Entrance Examination Board. He said that a conference had been held with the committee of the New England Association of Chemistry Teachers to formulate a syllabus for a two-year course including both Physics and Chemistry.

Upon motion of Mr. Miller it was voted that the E.A.P.T. request the College Entrance Examination Board in its revision of the syllabus in Physics to choose such material that the resulting syllabus will be ten per cent less than the present syllabus in content.

Following is the letter sent by the Chairman of the Committee to the College Entrance Examination Board:

May 10, 1937
East Boston High School
East Boston, Mass.

*Mr. Carl C. Brigham, Research Secretary
College Entrance Examination Board
New York, N. Y.*

DEAR MR. BRIGHAM:

Mr. Lawrence A. Howard, President of the Eastern Association of Physics Teachers referred your letter of August 25, 1936, requesting the E. A. P. T. to aid the College Entrance Examination Board in formulating a curriculum designed for the two-year course in Physics and Chemistry combined to the Committee on College Entrance Requirements of which I was chairman.

Our committee worked on a Physics' outline for a one-year course and marked the topics which were considered as common to both Physics and Chemistry. I am sending you a copy of that outline. A preliminary report was submitted to the Assoc. at the December meeting. Then a syllabus was mailed to each member in January for comments. A revised syllabus was submitted at the March meeting and was accepted by a vote of the Association as its recommendation to the C. E. E. B.

The Physics Committee met with a similar committee of the New England Association of Chemistry Teachers and discussed the requirement for the two year course in Physics and Chemistry combined. The Chemistry Committee prepared an outline for a one year course in Chemistry with the ground common to Physics, so marked. You will receive that from the Chemistry Association.

After several joint meetings and much discussion the joint committee made the following recommendation which was voted by the E. A. P. T. at its May meeting:

A joint committee of the Eastern Physics Teachers Association and the New England Association of Chemistry Teachers has given consideration to the syllabuses which are to be submitted by these associations to the College Entrance Examination Board to cover one year courses in these subjects. The committee approves of these as a satisfactory basis for a two-year course in Physical Science and it has indicated certain topics in the syllabuses which is common ground in the two subjects.

The committee believes that it is unwise at this time to attempt to formulate a definite outline for a two-year course in physical science, because of the lack of experience of teachers in this field. It therefore will ask teachers who wish to undertake the two-year program to make use of the two first-level outlines, to experiment with the or-

ganization of merger courses and to report their findings to the joint committee of the two associations for further consideration.

At the May meeting it was also voted to request the C. E. E. B. to make a 10% reduction in the amount of material to be covered by the new one-year syllabus in Physics.

Trusting that our recommendations may be of some service to you and expressing the desire to be of whatever further help we may, I am

Very truly yours,

BURTON L. CUSHING

*Chairman of College Entrance Committee
of the Eastern Association of Physics Teachers*

President Howard expressed his hearty thanks to the officers, committee members and other members who have been so kind and helpful, and his appreciation of the coöperation of all during his administration.

It was voted that the joint meeting of the Eastern Association of Physics Teachers and the Physics Club of New York express to Connecticut College, the Coast Guard Academy and the Submarine Base sincere thanks for the entertainment received at the meeting in New London, May 1.

REPORT OF COMMITTEE ON NEW BOOKS AND MAGAZINE LITERATURE

MR. CARL W. STAPLES, *Chairman, Chelsea High School*

MR. KENNETH L. GODING, *Attleboro High School*

MR. THOMAS C. BAILEY, *Hartford High School*

NEW BOOKS

First Principles of Physics. 1937 edition. Revised by Fuller, Brownlee, and Baker. Allyn and Bacon, publishers.

With new introductory survey of Physics and its place and importance in modern life.

Weather Rambles, by W. J. Humphreys. Williams and Wilkins, publishers. 265 pages. Illustrated. \$2.50.

A very interesting book by a man who is often called the veteran professor of the physics of the air. Deals with all sorts of strange behaviors of the air, such as tornadoes, cyclones, hail, rain, snow, and the factors and forces that cause them.

Unit Tests in Physics, by Burdick & Duddleston. L. W. Singer Company, publishers. 79 pages.

Contains 16 unit tests in Physics, each test containing 25 questions. Directions for scoring are given. Tests appear interesting and could be used to advantage in many schools.

MAGAZINE LITERATURE

Astrophysics

"Collecting Data on Meteors and Fireballs," by Raymond E. Critley, *Popular Astronomy*, April, 1937. P. 190-195.

"The New Universe," by Harlan True Stetson (A historical survey), *Popular Astronomy*, April, 1937. P. 175-189.

Atomic Physics

"The Solid Matter Mystery," or "Why is a Glass?" by Philip M. Morse, *Technology Review*, April, 1937. P. 237.

"New Trap for Atoms in Photographic Film," *Science*, N.L. 31: 203-4. March 27, 1937.

"Transmutation of the Elements," by R. D. Potter, *Science*, 85: sup. 8. February 26, 1937.

Aviation

"New Plane Planned," *Science*, 85: sup. 13. March 19, 1937.

"Latest Blind Landing System Explained by Model" (diagram), *Popular Mechanics*, May, 1937. P. 728-9.

"Splendid Amphibian," by A. Klemin, *Scientific American*, April, 1937. P. 245.

"Projected Wind Tunnel," by J. C. Hunsaker, *Scientific Monthly*, April, 1937. P. 390.

Cosmic Ray

"Cosmic Ray Recording Station in Mexico," *Science*, 85: p. 282. March 19, 1937.

Diesel Engines

"The Diesel Engine and its Possibilities," by Sumner B. Ely, *Scientific Monthly*, April, 1937. P. 358-362.

Economic Physics

"The Automobile Industry and the Young Engineer," by C. J. Freund, *Mechanical Engineering*, April, 1937. P. 227.

Electricity

"A New Type of Circuit Breaker," by Frank A. Eastom, *Power Plant Engineering*, April, 1937. P. 226-7.

Historical Physics

"Longest Eclipse," by D. Dietz, *Current History*, 46: 94-5. April, 1937.

"Grand Canal Panorama," by Willard Price (with 32 illustrations), *National Geographic Magazine*, April, 1937. P. 487-514.

"The Glass Industry of Cleveland, N. Y.," by Mary E. Davison, *Antiques*, April, 1937. P. 183-185.

"Curious 19th Century Locomotive Design," by H. A. Robinson, *English Mechanics*, April 2, 1937. P. 574.

"Engineering Achievements of George Westinghouse as Recalled by Former Associates on his Ninetieth Anniversary" (profusely illustrated), *Mechanical Engineering*, April, 1937. P. 263-274.

"Colonial Lamps Burn Again" (Modern Light for a Colonial City) (Restoration of Williamsburg, Va.), by H. J. Chase, *Electric Journal*, March, 1937. P. 114.

Hydraulics

"Submerged Hydroelectric Plant Saves Money in Germany," *Power*, April, 1937. P. 221. (See also reference in last report to Leipzig "Illustrierte Zeitung.")

Invisible Radiations

"X-Rays and Neutrons Don't Act Alike on all Life," *Science News Letter*, April 3, 1937. P. 216. (Vary in destructive effects on different living things. Results of experiments on types of living material are given.)

"Pneumatic Tube Delivers Radium Bombs from Safe," *Science News Letter*, 31: 200. March 27, 1937.

"Fatal Transformations; X-rays Destroy Certain Kinds of Cells," *Science News Letter*, 31: 212. April 3, 1937.

Laboratories

"World's Highest Laboratory Now Open on Mt. Evans; Joint Project of the Mass. M. I. T., and the Univ. of Denver," *Science News Letter*, 31: 220. April 3, 1937.

"Biographical Sketch of W. F. A. Ellison, Astronomer and Director of Armagh Observatory," *Scientific American*, April, 1937. P. 254-7.

Meteorology

"Weather Data By Radio from Captive Balloons" (diagrams), *Scientific American*, April, 1937. P. 240-241.

"Always Fair Weather," by Henry F. Pringle, *American Magazine*, April, 1937. P. 86. (Discusses reason for air-conditioning, what it will cost, and what one may expect for one's money.)

Microscope

"Micro-photography or Photomicrography?" by W. J. Luyten, *Science*, 85: 242. March 5, 1937.

New Equipment

"Electric Underlighted Drafting Table," by C. Padgett Hodson (with plan and illustrations), *The Rudder*, April, 1937. P. 33.

Oscilloscope

"Easily Built Oscilloscope Makes Sound Visible" (diagrams), *Popular Science Monthly*, May, 1937. P. 72-3.

Philosophy

"Les Paradoxes de Relativité sur le Temps," *Revue Philosophique*, Jan.-Feb., 1937. P. 10-47.

Photography

"Dihatorscope takes Guesswork out of Exposure" (with diagrams), *Popular Mechanics*, May, 1937. P. 754-7.

"Work-Desk for the Photographic Amateur," by E. F. Wheeler, *American Photography*, April, 1937. P. 246-9.

"Enlarging Hints," by A. Wolfman, *American Photography*, March, 1937. P. 214; April, pp. 280-1.

"Photomicrography for the Professional and Amateur," by H. H. Poole (diagrams), *American Photography*, April, 1937. P. 262-8.

Radio

"Scientist Still Seeking Cause of Interstellar Static," *Science News Letter*, April 3, 1937. P. 213.

"Science on the Radio," by W. Davis, *Science*, 85: 258. March 12, 1937.

"One-Tube 6-7 Short-Wave Receiver for Beginners" (diagram), *Popular Mechanics*, April, 1937. P. 578-9.

Stresses

"Soil Science," by B. K. Hough, Jr., *Technology Review*, April, 1937. P. 232.

Turbines

"Mercury in Small Boilers," *Power Plant Engineering*, April, 1937. P. 213.

Velocities

"Determine Speed of Shells by Firing Through Light," *Science News Letter*, April 3, 1937. P. 212. (Photographs and description of apparatus.)

Miscellaneous

"Next Step in Science and Education and the Finds Behind Them," by F. P. Keppel, *Vital Speeches*, April, 1937. 3: 376-80.

"Science in Adult Education," *Science News Letter*, 31: 256. March 6, 1937.

"Dissemination of Scientific Literature by Means of Microfilms" (outline of a filmothec service), by A. Seidel, *Science*, 85: 240-2. March 5, 1937.

"Boy Scientists Make Astounding New Discoveries," by E. W. Murtfeldt, *Popular Science Monthly*, 130: 30-1. May, 1937.

Mr. Samuel Yaknowitz, President of the Physics Club of New York opened the joint session, speaking as follows:

"It is indeed a privilege to initiate the program on this occasion. When I first communicated with Mr. Howard regarding the possibility of a joint meeting, I felt the thrill of a gambler who takes a long chance. Now that

the incredible has occurred, I am convinced that our joint meeting has been long overdue.

"I do not wish to inject into this occasion any special purpose other than the full enjoyment, by all of us, of the splendid program that has been arranged. However, it may be well to mention in passing that there are matters of common professional concern that organizations like ours can consider jointly, if close contact can be established:

The problem of curriculum revision; Desirable changes in college entrance requirements; The development of visual aids for science instruction; The reasons for our failure to influence, generally, the mental habits and outlook of our pupils in the direction of the scientific point of view.

"But, whatever the problems may be that can engage our joint attention, no human relationship is complete without friendship. If this meeting can serve but to lay a foundation of mutual good will between our societies, it will have served its main purpose adequately.

"Mr. Howard told you that the idea for the meeting was mine. I accept the responsibility for any deficiencies. But the pleasures and satisfactions of the meeting you owe entirely to those who made it a reality: To Mr. Howard, who nursed and guided the project from the beginning; To Mr. John L. Clark, of the Eastern Association, who made all the arrangements; To the commanding officers of the United States Coast Guard Academy, and those of the Submarine Base of the United States Navy, for their cooperation with the program; To the administrative officials of the Connecticut College for Women, for their hospitality in making the college our headquarters for the day.

"It is now my pleasure to present our official host, Dr. G. K. Daghljan, Professor of Physics at The Connecticut College for Women."

Professor Daghljan, after greeting the association on behalf of the President of the college, gave a short talk. The main thing he pointed out was that a physicist or physics teacher can extend certain principles of physics to fields that fall outside his sphere by analogy or parallelism. As an example, he said, take Newton's second law of motion. Ever so many problems in the field of pure and applied physics are solved by the equation $f=ma$ or $f=ma/g$ which represent the above law in symbols. This law can be stated in words as follows: Change of motion produced in a body by the action of a force is directly proportional to the magnitude of the force and time during which the force has acted, and is inversely proportional to the mass of the body.

This principle can be applied by analogy to the problem of selling certain goods to a public or putting over some ideas to a community. The former is a pure case of salesmanship and the latter propaganda. Let us see how it applies. Put *willingness to buy* on the part of public or *conversion to the idea* in place of the *change of motion* in Newton's law. Let the magnitude, inertia, prejudice, etc. of the public stand for *Mass*. Finally, let the usefulness, attractiveness, salestalks, authority of the sellers or the preachers stand for the *force*. Then, it is apparent that by applying these forces over a long period of time, any article and any idea can be sold to any public. This is constantly happening in our present civilization.

Professor Daghljan gave other examples of this and other laws of physics and showed how they work in social, economic, political and domestic fields. He was particular in warning the audience that this line of thought must be used with the distinct understanding that *it is not Physics* but *an analogy* that we can draw from physics.

And he concluded by saying that a physicist not only can invent new machinery and appliances and manufacture them, but can supply the prin-

ciple of salesmanship to dispose of the articles. Not only can he build stronger war machinery and thereby upset the balance of political equilibrium, but he can point out the ideal principle of democracy by drawing analogy from the law of concurrent forces and their resultant.

SUBMARINE ESCAPE

By LT. (JG) GEORGE A. SHARP, U.S.N.

It is my privilege and pleasure to speak to you this afternoon about the devices and methods which the United States Navy has developed to reduce the hazards of duty in submarines. Of these devices I will particularly describe the Submarine Escape Device, commonly called the "Momsen Lung." Other safety features will be mentioned in connection with, or compared with, the use of the Lung. I will also describe the training in the use of the safety devices, which each man must have before starting duty in submarines.

Previous to 1928 we had no satisfactory means of saving the crew of a submarine which was so damaged by collision, gunfire, explosion, etc., that the submarine itself could not be raised by any means available within the submarine. You probably all remember that when the U.S.S. S-4 was sunk by collision in 1927 members of the crew were alive three days after the vessel went to the bottom. It was impossible to rescue them! The entire crew perished.

Following closely the sinking of the U.S.S. S-51 (1926) as it did, the result was an intensification of the search for apparatus and methods for saving the crews of sunken submarines. The Navy Department called upon the Navy and the public for ideas and inventions. Many suggestions were submitted, by men in all walks of life. All were considered and many were accepted and used. The best are now incorporated into the design of our submarines, or are used on board or in connection with submarines.

The "Momsen Lung" was one of the features introduced. It was designed by one of our naval officers, Lieut. Momsen. It was first used in 1928. Many changes have been made since that time but the principles of its use remain about the same. We are constantly trying to improve on design and methods. We have on display at the Submarine Escape Training Tank one of each model, so that the development may be readily followed.

The Submarine Escape Training Tank began operating in August, 1930. It is 18 feet in diameter, 137 feet high, and holds about a quarter of a million gallons of salt water. The height of the water column above the lowest point of entry is 100 feet. It is equipped with an elevator, the use of which is extremely important in case of accident to a man using the "Lung." There is also an electrically operated diving bell which adds greatly to the safety of training. The diving bell can be used to descend to the bottom of the Tank. There are escape locks located on the outside of the Tank at 18 feet and 50 feet from the water surface. Necessary pumps, filters,

chlorinators, etc., are installed to insure a good supply of clean water.

The "Lung" consists essentially of a rubberized fabric bag containing a valve for charging, a valve for releasing excess pressure, a canister (which in use contains a renewable supply of soda lime), the necessary air-passages, and has attached the straps and clips necessary to adjust the "Lung" on the wearer.

In preparing to use the "Lung" the wearer adjusts the neckstrap so that the mouthpiece assembly, which is on the upper end of the concentric breathing tubes, comes on a level with his mouth. The back-strap is passed around the body and secured with about two inches of slack. The pants-clips, one on each side, are clipped to the bathing trunks or trousers of the wearer. Then, with the lower part of the "Lung" in the water, it may be charged with oxygen. The charging valve is similar to a tire valve. The wearer then grips the mouthpiece with his teeth and lips, puts a nose clip on his nose, opens the mouthpiece valve, and starts breathing. He must breathe through his mouth. He is now using the "Lung" and can breathe while entirely submerged in water.

Having described the "Lung," the manner in which it is prepared for use, and the Training Tank in which it is used, I will now outline the procedure by which a man qualifies in the use of the "Lung."

The candidates are given a rigid physical examination, particular attention being given to ears, nose, throat, lungs, and heart. They are then given thorough instruction, in the purpose, construction, and method of using the "Lung," with emphasis placed on the procedure to be followed if they encounter any of the six difficulties which may be encountered. After this instruction they are subjected to an air pressure of 50 pounds per square inch. Frequently candidates have difficulty in equalizing the pressure on the inner side of the eardrums as the pressure increases on the outer side. Occasionally men get severe sinus pains. Either difficulty is usually temporary and is frequently caused by the common head "cold." Candidates who are so afflicted are taken out while the pressure is again increased on the other candidates until the 50 pound maximum is reached. The purpose of the pressure test is two-fold: first, to demonstrate to the candidates that they can be subjected to this pressure (about 112 feet of sea water) without harmful effects; second, to eliminate those who cannot equalize the pressure on their eardrums, before they are subjected to pressure while in the water.

The next step in training is in using the "Lung" at the surface of the water in the "Tank." Each instructor takes two candidates. The "Lungs" are put on and adjusted, and the candidates go down ladders into the water until they are submerged from their feet to their armpits. The instructor then reviews the instructions previously given, charges the "Lung" with oxygen, sees that the mouthpiece is properly held and that the valve is open and the candidate is breathing properly, then directs the candidate to go down the ladder until he is completely submerged and take a specified number of breaths.

After the candidates assure themselves that they can breathe underwater and have become accustomed to using the "Lung" they are ready for the next step, an escape from a depth of 12 feet. An instructor takes two candidates in the diving bell and lowers the bell until the platform on which they stand is 12 feet below the surface of the water. To each side of this platform is attached a line, the other end of which is secured above the surface, and at the middle of which is a marker. The "Lung," worn by each candidate, is charged with oxygen, the candidate reaches out and grasps the line, then ducks out of the bell and slides slowly up the line until he reaches the marker. He then stops and takes a specified number of breaths before resuming his ascent.

Two such escapes are made from a depth of 12 feet before progressing to the next step which consists of two escapes from the 18 foot side lock. Nine candidates and two instructors ride down in the elevator, outside of the Tank, to the 18 foot level. There they enter the side lock which has a door giving access from the passageways and a door giving access to the inside of the Tank. With the instructors and candidates in the lock, the outer door is closed. Then the lock is flooded up, the water level being so adjusted by venting or admitting compressed air that when the water reaches the top of the inner door the pressure in the lock corresponds to a head of 18 feet of water. The inner door (into the Tank) is then opened. A buoy is pushed out through the doorway and carries one end of a line up to the surface of the water in the Tank. The other end of the line is secured in the lock. A marker is secured on the line 10 feet from the surface. Each candidate has his "Lung" charged, grasps the line, ducks out of the lock and slides slowly up the line. In making the first escape from this depth, a stop is made at the marker. On the second trip, a continuous ascent is made.

Upon successful completion of the training outlined the candidate is considered as qualified in the use of the "Lung." Training at deeper depths is entirely voluntary.

The procedure in making escapes from the 50 foot lock is similar to that at the 18 foot lock. The only difference being an additional stop 20 feet from the surface. While candidates are making escapes from the 50 foot lock an instructor is stationed in the diving bell at a depth of about 25 feet. He can watch the man ascending and if necessary take the man into the bell, if in his opinion the man is doing something wrong and is likely to get into danger.

In making escapes from a depth of 100 feet the candidates and three instructors enter the dummy submarine compartment and close the door. The compartment is flooded up as a submarine compartment would be and the escape is made up through a hatch as in a submarine. On the first ascent from this depth stops are made at 50 feet and each 10 feet thereafter. The second ascent is continuous. The instructor in the diving bell takes station at a depth of 50 feet. Telephones and line signals are used

at the surface, in the diving bell, and in the 100 foot compartment to keep a close check on the progress of the men up the line.

The feature of the "Lung" which makes possible the repeated breathing of the charge of oxygen is the soda lime (so called, though not exactly correct) which separates the carbon dioxide of the exhaled breath from the oxygen before the oxygen is again inhaled. The breathing tubes have mica disc valves which direct the exhaled breath directly into the bag and insure that the inhaled breath is drawn through the soda lime. When charging the "Lung" it is always fully inflated and contains sufficient oxygen for 30 minutes. As the proper speed of ascent is fifty feet per minute it will be seen that the "Lung" holds sufficient oxygen for escape from any depth from which escape is possible. It has been used at a depth of over 300 feet.

It is vital that the user of the "Lung" breath continually while ascending and that his speed of ascent be about 50 feet per minute. If the man making the ascent holds his breath or ascends rapidly, the expansion of the oxygen in his lungs (due to the decrease in the water pressure) will force bubbles of oxygen through the walls of his lungs, causing air embolism. The bubble may lodge in his heart, brain, or in a joint, which will cause intense pain or unconsciousness and may prove fatal. The treatment for air embolism consists primarily of getting the patient under pressure again as soon as possible. The pressure reduces the bubble to such size that it may pass through the circulatory system to the lungs. The pressure is reduced very slowly as in the treatment of compressed air illness. There is always a doctor present during the phases of training which involve pressure.

We tell the candidates of this danger but stress the fact that if they follow instructions implicitly they will avoid the danger. The fact that over fifteen thousand escapes have been made successfully in this Tank, with an extremely small percentage having any difficulty at all, seems to me to justify our claim.

All of our submarines are now so constructed and equipped that in case of sinking, all of the crew (except possibly those in the damaged compartment) will be able to escape. This of course is not true in case the submarine sinks in such a depth of water that the excessive pressure will crush the hull. Lungs, oxygen, compressed air, escape lines and equipment are all part of the standard equipment of a submarine.

The submarines are also equipped for use of the "Rescue Chamber" in effecting rescue. Its use permits the rescue of the crew of a sunken submarine without subjecting them to pressure or even getting wet. It has, however, many disadvantages which make its successful use doubtful. It is large and heavy and must be taken to the place where the submarine is sunk. It is extremely difficult to handle in a heavy sea. The Submarine Escape Device seems to be the best solution to the rescue problem. We hope to find a better solution. We hope no rescue device or method will be needed, but if the occasion arises we want to be ready. Possibly a mem-

ber of one of the two organizations assembled here will be able to help us to a better solution of the problem.

In closing I would like to urge you to visit the Escape Training Tank during your scheduled visit to the Submarine Base this afternoon. You are also cordially invited to visit us any day during authorized visiting hours.

The opinions or assertions herein expressed are mine, and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1495. *Edgar A. Rose, Rochester, N. Y., Arthur Danzl, Collegeville, Minn.*

1493. *Saul Ikler, Albany, N. Y.*

1484. *O. D. Johnson, Olney, Philadelphia H. S. Math. Club.*

1496. *Proposed by A. R. Haynes, Tacoma, Washington.*

Prove (without using the radical values of the functions):

$$\frac{1}{1 + \sin 15^\circ - \cos 15^\circ} = \frac{1}{\sin 30^\circ} + \frac{1}{\sin 45^\circ}$$

Solution offered by Norman Greenspan, Lincoln High School, Brooklyn, N. Y.

$$\frac{1}{1 + \sin 15^\circ - \cos 15^\circ} \cdot \frac{1 - (\sin 15^\circ - \cos 15^\circ)}{1 - (\sin 15^\circ - \cos 15^\circ)} = \frac{1 + \cos 15^\circ - \sin 15^\circ}{\sin 30^\circ}$$

$$\begin{aligned}
 &= \frac{\sin 45 + \sin 45 \cos 15 - \sin 45 \sin 15}{\sin 30 \sin 45} = \frac{\sin 45 + \cos 60}{\sin 45 \sin 30} \\
 &= \frac{1}{\sin 30} + \frac{\cos 60}{\sin 45 \cos 60} = \frac{1}{\sin 30} = \frac{1}{\sin 45}.
 \end{aligned}$$

Solutions were also offered by Charles W. Trigg, Cumnock College, Los Angeles, J. B. King, Corsica, Pa., David Rappaport, Chicago, Hyman Marcus, New York, Bert Fowler, Centralia, Ill., the proposer.

1497. Proposed by Aaron Buchman, Buffalo, N. Y.

Given an isosceles triangle ABC with base AC extended through C to any point D . On segment BD , a point, E , is taken such that $\angle BAE = \angle BDA$. FE is perpendicular to BD and meets AD in F . Prove that $AF:FC = AE:EC$.

Solution by J. Slavin, Brooklyn, N. Y.

Draw EC . $\angle r = \angle BCA - \angle p = \angle A - \angle p = \angle e$.

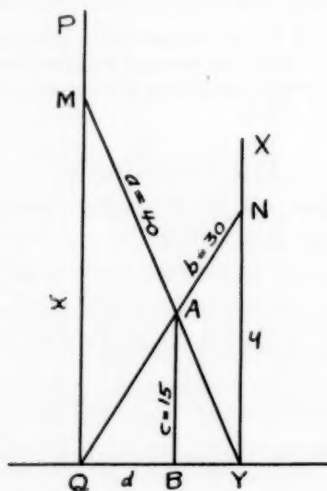
Therefore the quadrilateral $ABEC$ is concyclic. Hence $\angle s = \angle p$. Now $\angle 4$ is supplementary to $\angle BEC$; also $\angle BEC$ is supplementary to $\angle A$. Therefore $\angle 4 = \angle A$. Also $\angle 3 = \angle BCA = \angle A$.

Hence $\angle 4 = \angle 3$. Since EF is perpendicular to BD , $\angle 1 = \angle 2$ and EF is the bisector of $\angle AEC$ which gives us the relation $AF:FC = AE:EC$.

Solutions were also offered by Hyman Marcus, New York City, D. F. Wallace, Walter H. Carnahan, Indianapolis, Allin Jackson, Kamloops, B.C., Julius Freilich, Brooklyn, V. C. Bailey, Emory, Va., Harold Sogin, Chicago, Jack Demsey, Wilmington, Calif., A. R. Haynes, Charles W. Trigg, Los Angeles, and the proposer.

1498. Proposed by C. R. Green, Winnipeg, Canada.

PQ and XY are two walls at right angles to QY . MY and NQ are two ladders, MY being 40 ft. long and NQ , 30 ft. long. If the ladders meet at A , which is 15 ft. above QY , find the length of QY .



Solution by Charles W. Trigg, Cumnock College, Los Angeles.

Set $MQ = x$, $NY = y$, $NQ = b = 30$, $MY = a = 40$, $AB = C = 15$, and $QY = d$.

Then $x^2 = a^2 - d^2$ and $y^2 = b^2 - d^2$ so $x^2 - y^2 = a^2 - b^2 = 700$. From similar triangles, $\frac{c}{y} = \frac{QB}{d}$ and $\frac{c}{x} = \frac{(d-QB)}{d}$. Adding, $c\left(\frac{1}{x} + \frac{1}{y}\right) = 1$, hence $\frac{1}{\sqrt{700+y^2}} + \frac{1}{y} = \frac{1}{15}$. This yields the equation, $y^4 - 30y^3 + 700y^2 - 21000y + 157500 = 0$. By Horner's method of approximation the positive root between 15 and 30 is found to be 25.3841. Then $d = \sqrt{900 - y^2} = 15.989$ ft. = 16 ft. (approx.).

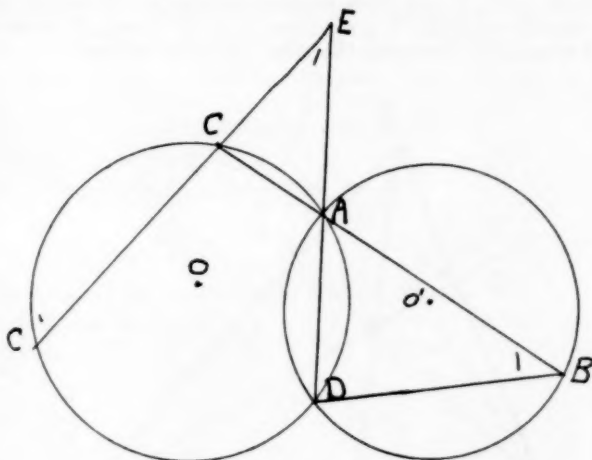
Lest it be suspected that an exact value of 16 feet has been obscured by the approximation processes, let it be noted that Simon Vatriquant has shown that if a, b, c and d are integers, then x and y also are integers. Also for $a > b$, the smallest integral set of values for a, b, c, d, x and y are 105, 87, 35, 63, 84 and 60. [American Mathematical Monthly, p. 642-43, Dec. 1936.]

A solution giving the same length of QY was offered by A. R. Haynes, Tacoma, Washington.

Hyman Marcus found 28.4 as length using the same equation as Mr. Trigg. John P. Exposito, Chicago, offered 28.4 as the required length.

1499. Proposed by Cecil B. Read, University of Wichita, Kansas.

Given two circles intersecting in A , to draw through A a secant ABC , intersecting the circles at B and C such that a given length shall be a mean proportional between AB and AC .



Solution by the proposer.

Let the common chord AD be produce to E such that a given length is the mean proportional between AD and DE . At E construct angle AEC equal to the angle inscribed in the segment of circle O' , with AD as a chord. Let EC cut the circumference again in C' . By similar triangles it is readily seen that either AC or AC' satisfies conditions.

Solutions were also offered by D. F. Wallace, A. R. Haynes, Aaron Buchman, Buffalo, N. Y., Hyman Marcus, New York, D. L. MacKay, New York.

1500. Proposed by Norman Anning, University of Michigan.

Every binomial coefficient except 1 is expressible as the sum of two bino-

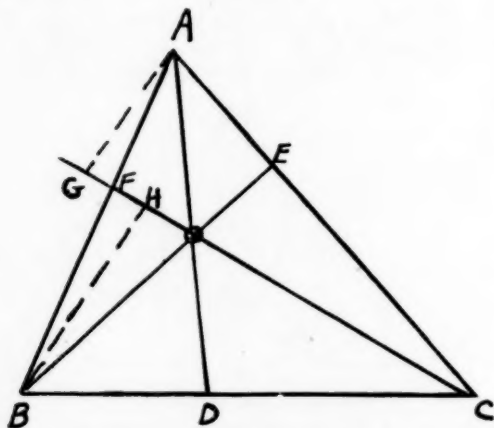
mial coefficients. Prove that every trinomial coefficient $\frac{(p+q+r)!}{p!q!r!}$ where p, q and r are positive is expressible as the sum of three trinomial coefficients.

Solution offered by Hyman Marcus, New York.

$$\begin{aligned}\frac{(p+q+r)!}{p!q!r!} &= \frac{(p+q+r-1)!}{(p-1)!(q-1)!(r-1)!} \cdot \frac{p+q+r}{pqr} \\ &= \frac{(p+q+r-1)!}{(p-1)!(q-1)!(r-1)!} \left[\frac{p}{pqr} + \frac{q}{pqr} + \frac{r}{pqr} \right] \\ &= \frac{(p+q+r-1)!}{(p-1)!(q-1)!(r-1)!} \left[\frac{1}{qr} + \frac{1}{pr} + \frac{1}{pq} \right] \\ &= \frac{(p+q+r-1)!}{(qr)(p-1)!(q-1)!(r-1)!} + \frac{(p+q+r-1)!}{(pr)(p-1)!(q-1)!(r-1)!} \\ &\quad + \frac{(p+q+r-1)!}{(pq)(p-1)!(q-1)!(r-1)!} \\ &= \frac{(p+q+r-1)!}{(p-1)!(q)!(r)!} + \frac{(p+q+r-1)!}{(p)!(q-1)!(r)!} + \frac{(p+q+r-1)!}{(p)!(q)!(r-1)!}\end{aligned}$$

1501. *Proposed by C. T. Adams, New Orleans.*

In a triangle ABC , F and E are variable points on AB and AC respectively. If $AB/FB + AE/EC$ is a constant, find the locus, O , of the intersection of BE and CF . Show that the area of BOC is constant.



Solution by J. Slavin, Brooklyn.

Draw BH and AG , the altitudes of triangles BOC and AOC , respectively.
Draw AOD

$$(1) \quad \frac{\Delta COA}{\Delta BOC} = \frac{AG}{BH} = \frac{AF}{FB}. \text{ Likewise, we can prove } \frac{\Delta ABO}{\Delta BOC} = \frac{AE}{EC}.$$

$$\text{Similarly, } \frac{\Delta CAO}{\Delta COD} = \frac{\Delta ABO}{\Delta BOD} = \frac{AO}{OD}$$

$$\text{Therefore } \frac{AO}{OD} = \frac{\Delta CAO + \Delta ABO}{\Delta COD + \Delta BOD} = \frac{\Delta CAO + \Delta ABO}{\Delta BOC}.$$

$$\text{From (1) } \frac{AF}{FB} + \frac{AE}{EC} = \frac{\Delta COA + \Delta ABO}{\Delta BOC} = \frac{AO}{OD}.$$

But $AF/FD + AE/EC$ is a constant. Therefore AO/OD is a constant. Therefore O is the vertex of a triangle whose base is BC and whose altitude is constant. Its area is therefore constant and the locus of O is a line parallel to BC at a distance equal to the product of the ratio OD/AD and the altitude of ΔABC .

Solutions were also offered by Hyman Marcus, Charles W. Trigg, A. R. Haynes, Hugo Brandt, D. L. MacKay, Allin W. Jackson.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the editor such solutions.

For this issue the Honor Roll appears below:

1496. *Le Roy Simkins, Corsica (Pa.) H. S.*

PROBLEMS FOR SOLUTION

1514. *Proposed by William W. Taylor, Port Arthur.*

Construct a triangle, given the difference of the base angles, the difference of the angles made by the median to the base, and the difference of the projections of the other two sides upon the base.

1515. *Proposed by G. S. N. Ayyar.*

If x be a proper fraction, show that

$$\frac{x}{1-x^2} - \frac{x^3}{1-x^6} + \frac{x^5}{1-x^{10}} - \cdots = \frac{x}{1+x^2} + \frac{x^3}{1+x^6} + \frac{x^5}{1+x^{10}} + \cdots$$

1516. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Let each integer in the series from 1 to n be multiplied by the sum of the positive integers less than it. Prove that the sum of these products has the form

$$\frac{(n-1)n(n+1)}{4!} (3n+2).$$

1517. *Proposed by A. R. Haynes, Tacoma, Washington.*

In a triangle ABC , angles A and B are given. If P is a point outside the triangle, but closer to A than to B and C , and if a, b, c , are the distances from P to A, B and C respectively find the length of the sides of the given triangle.

1518. *Proposed by A. R. Haynes.*

Proves by transformation formulae that

$$\csc 30 + \csc 45 = \frac{1}{2}(\tan 82.5 - \tan 37.5).$$

1519. *Proposed by Hugo Brandt, Chicago.*

A family of circles on one side of a given line are tangent to the line at a fixed point. On each circle two points are determined whose distance from

the line is $(d - e)$, d being the variable diameter of the circle and e , a fixed constant. Find the locus of the variable points.

EDITOR'S NOTE: In problem 1508 the height of the flag pole which was 100 ft. was not given.

SCIENCE QUESTIONS

October, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings. Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific). Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers to make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

As a Mode of Recognizing contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 190 contributors have already been admitted to Membership. Classes or individuals, may become members by proposing a question or submitting an answer.

JOIN THE GQRA

GQRA—NEW MEMBERS—OCTOBER, 1937

185. H. M. Zerbe, Wilkesbarre, Pa.
186. Franklin Edwards, Middleport, Ohio
187. Harold Kauff, Middleport, Ohio.
188. Carl Nichols, Middleport, Ohio.
189. Dolores Kowalewski, Mercy H. S., Milwaukee, Wis.
190. Mathilda Platta, Mercy H. S., Milwaukee, Wis.
191. Carolyn Marks, Mercy H. S., Milwaukee, Wis.
192. James Fitzpatrick, Ringling, Oklahoma.
193. Audrey Komarek, Mercy H. S., Milwaukee, Wis.
194. V. C. Bailey, Emory & Henry College, Emory, Va.
195. David Halliday, West Homestead, Pa.

HELP FOR FORMO

805. Jerome C. Formo, GQRA No. 102, proposed this "teaser" for the GQRA Picnic at Pen 'Bryn, Geneva, Ohio, on August 1, 1937.

He says, "I have always held that the correct number would be —; but a learned University graduate who spoke to me in terms of calculus and differential equations so twisted me up with his fourth dimensional calculations that I began to wonder if the poor chickens would ever lay any more eggs."

A biologist and a physicist at the Picnic cou'd not agree. Here is the question (It is not claimed to be "scientific")—

"If a hen and a half lay an egg and a half in a day and a half. How many eggs will six hens lay in six days?"

SOME VIBRATION QUESTIONS

806. *The Proposer wishes to remain anonymous.*

1. Is it possible to send electrical waves in a desired direction?
2. Can sound waves and vibrations be produced so large and so loud that they can destroy some solid structure?
3. How far can magnetic waves be sent through ordinary air?
4. Can electrical waves be made to magnetize a motor and stop its running?

FOR THE FLIERS

807. *Proposed by John M. Michener, (GQRA No. 117) Wichita, Kansas.*

A recent statement in a scientific journal was to the effect that compressing the atmospheric air to standard pressure by a supercharger on a stratosphere airplane at a height of 40,000 feet would raise the temperature from -58°F. to 302°F. The pressure of the atmosphere at that height is 140 mm. What volume of outside air would have to be compressed to one cubic foot to get the increase in temperature mentioned?

WHENCE CAME, "SEND MORE MONEY,"

791. *Charles W. Trigg (GQRA No. 20) says—*

"W. E. Buker (GQRA No. 22) solved this problem in *The American Mathematical Monthly*, 40, 177 (March, 1933). Prior to that it had appeared in *International Chess Review*, L'Echiquier (June, 1928), Brussels, and also in *Le Sphinx*. The solution is $9567 + 1085 = 10652$ so the sales manager was right and used commendable discretion in locating the decimal point."

ANSWERS, QUIZ OF MONTH FOR MAY, MULE PROBLEM

795. *Submitted by Charles W. Trigg (GQRA No. 20) Cumnock College, Los Angeles, California, from a collection of interesting mathematical and scientific questions collected by L. J. Adams, Santa Monica Junior College and published in the "Los Angeles Times."*

"Problem No. 14.—A mine contractor had two lots of metal bars. Eight of the large size were as heavy as thirteen of the small size bars. Altogether there were forty-nine bars of metal, which he wished to have carried over a mountain pass.

The contractor made a bargain with two brothers who owned seven mules, to transport the metal over the pass. He paid them an even number of dollars, which they divided equally between them. They took no other money with them on the trip.

Some of the mules were weaker than others, and it was necessary to

adjust the weight of the packs to the individual capacities of the mules. This was done, and no two mules carried the same weight of pack, although each carried seven bars, and no pack weighed as much as 300 pounds nor as little as 150 pounds.

After they were well started, one of the brothers found that he had left his pipe at the ranch. His brother had an extra one which was new, and sold it to him for just what he had paid for it, which was an integral number of dollars.

After this transactions the product of their respective money holdings (which were both prime numbers) was \$9 less than it would have been before the sale of the pipe and exactly \$70 more than the total weight of the seven packs of metal carried by the mules.

What was the weight of one bar of the larger size and what was the weight of the smaller bar?

Solved by the following—(Solutions are lengthy and will not be published unless there is an express demand.)

J. Bryns King (GQRA No. 88) Corsica Union High School, Corsica, Pa.

Hugo Brandt, (GQRA No. 133), Chicago, Ill.

W. R. Smith, (GQRA No. 176). Lewis Institute, Chicago, Ill.

H. M. Zerbe (elected to GQRA, No. 185), Wilkesbarre, Pa.

V. C. Bailey (elected to GQRA, No. 194), Emory & Henry College, Emory, Virginia.

David Halliday (elected to GQRA, No. 195), West Homestead, Pa.

Integral Answers are the same by all.

Large bars, 23 in number each weighing 39 lb.

Small bars, 26 in number each weighing 24 lb.

Each brother received \$40.

The pipe cost \$3.00.

There are also *seven* sets of fractional pound values:

39 $\frac{390}{497}$ lb.	24 $\frac{240}{497}$ lb.
39 $\frac{195}{502}$	24 $\frac{120}{502}$
38 $\frac{317}{512}$	23 $\frac{392}{512}$
38 $\frac{127}{517}$	23 $\frac{277}{517}$
37 $\frac{459}{522}$	23 $\frac{162}{522}$
37 $\frac{274}{527}$	23 $\frac{47}{527}$
37 $\frac{89}{532}$	22 $\frac{464}{532}$

W. R. Smith says:

"This happened in Susanville, California, on Sept. 31, 1888. The

brothers were named Jones. One was 38 years old and bald; the other 35 and red-headed."

Mr. Smith also writes as follows: The Science Questions Editor, has no defense. He takes things as he finds them. School boys are faithful and logical creatures. They say that back in 1905 on a Yale Examination in Algebra two yachts had to sail one 270 miles an hour and the other 180 miles an hour. The boys faithfully got the answers and none raised the question of reality. Here is Mr. Smith's comment—

DEAR MR. JONES:

I must confess that I do not like to see a statement like that in this problem in a journal devoted to science and mathematics.

How can a product of two money holdings be seventy dollars more than a weight? We expect such things in a newspaper but not in SCHOOL SCIENCE AND MATHEMATICS.

Perhaps I am hypercritical but an experience of about 50 years in writing examination questions and reading answers has taught me that, if there is the slightest looseness in the statement of a question some D.F. of a student will interpret the question in some other than the obvious way.

I feel that any statement in SCHOOL SCIENCE AND MATHEMATICS should be a model.

Very truly,
W. R. SMITH

SCIENCE IN THE DAILY NEWS

798. *From the Cleveland Plain Dealer (U.P.) of March 23, 1937.*

Ray Woods of St. Louis jumped from the San Francisco-Oakland Bridge 189 feet above the water into San Francisco Bay. "As he dropped, his body folded into the jack-knife from which he intended to emerge before reaching the water. A strong wind struck the plunging body and it remained in the folded posture as it struck the water." Hospital authorities said his back was broken.

How fast was Mr. Woods traveling at the time he struck the water?

How long had it taken him to fall? (189 feet.)

What was his impact? (Assuming a weight of 175 lb.)

Answer submitted by Robert E. McKay (GQRA, No. 172).

Three members of my physics class submitted solutions to Problem No. 798 found in the May issue of the SCHOOL SCIENCE AND MATHEMATICS, and asked that I send it (since all were the same) in to you. We hope this will not be too late for the June issue. Their names are Franklin Edwards (Elected to GQRA, No. 186), Harold Kauff, (Elected to GQRA, No. 187) and Carl Nichols (Elected to GQRA No. 188).

The first two questions are solved by the laws of falling bodies, while the third is by inertia.

(a) How fast was Mr. Woods traveling at the time he struck the water?

$$v = \sqrt{2gS} \quad v = \sqrt{2 \times 32.17 \times 189} \quad v = 110.27 \text{ feet per second.}$$

(b) How long had it taken him to fall?

$$v = gt \text{ (or) } t = \frac{v}{g} = 110.27 \div 32.17 \quad t = 3.43 \text{ seconds.}$$

(c) What was the impact? (This last question required some research in a college textbook, since it was beyond the scope of their high school text.)

The impulse when Mr. Woods struck the water would be $=mv$
 or $=175 \times 110.27 = 19,297$ foot-pounds per second.

The force of the impact, assuming it took him about 0.1 second to come to rest in the water, is

$$E = \frac{175 \times 110.27}{.1} \quad F = 192.970 \text{ poundals}$$

$$\text{(or) } F = \frac{192,970}{32.17} = 5,998 \text{ pounds (weight)}$$

One must keep in mind that the laws of falling bodies do not take into account the friction of the air, nor the current of wind that caused the sad plight of Mr. Woods.

SNAPDRAGON

800. *Why is the snapdragon flower so named?*

Answers by pupils of Sister Mary Stanislaus Costello (GQRA, No. 152), Mercy High School, Milwaukee, Wis.

Answer of Dolores Kowalewski. (Elected to GQRA, No. 189)

While trying to find why the name "snapdragon" had come to be given to a flower, I came across this following sentence, "The flowers are interesting because upon pressure on the sides of the snapdragon, they open like a mouth." An idea then came to me that maybe someone while doing this decided that this was a suitable name. The sides opening like a mouth might refer to a dragon and when the pressure was removed they closed with a snap. I think it is from this that the name "snapdragon" might have originated. I could find no other proof although I'm not saying my idea is correct. I just think so.

Other similar answers by Mathilda Platta (Elected to GQRA No. 190), Carolyn Marks (Elected to GQRA, No. 191) and Audrey Komarek (Elected to GQRA, No. 193), all of Mercy High School.

EXCHANGE OF BIOLOGICAL KNOWLEDGE

The Mercy Bio-ite Club wishes to exchange biological knowledge with other biology clubs of our country.

(Mercy High School, Milwaukee, Wisconsin)

WHAT IS NEW THIS FALL? (1937)

BOOKS RECEIVED

Laboratory Practice of Organic Chemistry, by G. Ross Robertson, Associate Professor of Organic Chemistry in the University of California at Los Angeles. Cloth. Pages xii+326. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$2.25.

Analytic Geometry and Calculus, by Max Morris, Associate Professor of Mathematics, Case School of Applied Science, and Orley E. Brown, As-

sistant Professor of Mathematics, Case School of Applied Science. First Edition. Cloth. Pages x+507. 15×23 cm. 1937. The McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price \$3.75.

Trigonometry, by John W. Branson, Professor of Mathematics, New Mexico State College of Agriculture and Mechanic Arts, and J. O. Hassler, Professor of Mathematics and Astronomy, University of Oklahoma. Cloth. Pages viii+198+73. 13.5×20.5 cm. 1937. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price \$1.75.

Science in the Elementary School, by W. C. Croxton, State Teachers College, St. Cloud, Minnesota. First Edition. Cloth. Pages xii+454. 14.5×23 cm. 1937. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price \$3.00.

The World of Atoms, by Arthur Hass, Professor of Physics in the University of Vienna and at present Professor of Physics in the University of Notre Dame (U.S.A.). Second Edition, Enlarged and Revised. Translated by George B. Welch, Northeastern University with the use of the translation of the first edition by Horace S. Uhler; Associate Professor of Physics, Yale University. Cloth. Pages xiv+183. 1937. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price \$3.00.

First Year College Mathematics, Part I—Trigonometry, by Volney H. Wells, Associate Professor of Mathematics in Williams College. Cloth. Pages vi+133. 15×23 cm. 1937. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price \$1.25.

First Year College Mathematics, Part II—Mathematical Analysis by, Volney H. Wells, Associate Professor of Mathematics in Williams College. Cloth. Pages ix+276. 1937. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price \$2.75.

Man in a Chemical World, by A. Cressy Morrison. Cloth. Pages xi+292. 16×22.5 cm. 1937. Charles Scribner's Sons, 597 Fifth Avenue, New York, N. Y. Price \$3.00.

The Progress Arithmetics, Books C and D, by Philip A. Boyer, Director, Division of Educational Research, Philadelphia Public Schools; W. Walker Cheyney, Elementary Research Supervisor, Philadelphia Public Schools; and Holman White, Superintendent, District 9, Philadelphia Public Schools. Paper. Book C, 201 pages, and Book D, 202 pages. 21×27.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 48 cents each.

Plants Useful to Man, by Wilfred W. Robbins, University of California, and Francis Ramaley, University of Colorado. Second Edition. Cloth. Pages ix+422. 14×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price \$3.50.

Plane Trigonometry with Tables, by Harvey Alexander Simmons, Associate Professor of Mathematics, Northwestern University, and Greenville D. Gore, Professor of Mathematics and Chairman of the Departments of Mathematics and Engineering Drawing, Central Y.M.C.A. College of Chicago. Cloth. Pages viii+201+81. 14×22 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$2.00.

Scientific Inference, by Harold Jeffreys. Cloth. Pages vi+272. 13.5×22 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.25.

Über Einige Neuere Fortschritte Der Additiven Zahlentheorie, by Edmund Landau. Paper. 94 pages. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$1.75.

Workbook and Laboratory Manual in Physics, by Hallie F. Turner, Science Department, Eastside High School, Paterson, New Jersey. Edited by Charles A. Culver, Professor of Physics, Carleton College, Northfield, Minnesota, and Louis T. Masson, Science Department, Riverside High School, Buffalo, New York. Paper. Pages viii+280. 20×27 cm. 1937. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y.

Workbook and Laboratory Manual in Biology, by C. S. Hann, Head of the Department of Biology, Central Senior High School, Kansas City, Missouri, and Mabel B. Stoddard, Teacher of Biology, Central High School, Flint, Michigan. Edited by Anna F. Moran, Head of the Department of Biology, Tilden Technical High School, Chicago, Illinois. Paper. Pages vi+346. 20×27 cm. 1937. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y.

Workbook and Laboratory Manual in Chemistry, by J. Byron Jones, Head of Science Department, El Paso High School, El Paso, Texas; Louis J. Mathias, Teacher of Chemistry, Thomas A. DeVilbiss High School, Toledo, Ohio; and Rayman S. Weiser, Teacher of Chemistry, Jessup W. Scott High School, Toledo, Ohio. Edited by Miles M. Miller, Head of the Science Department, Wilbur H. Lynch High School, Amsterdam, New York, and Earl M. Weiner, Head of the Department of Chemistry, Tilden Technical High School, Chicago, Illinois. Paper. Pages viii+312. 20×27 cm. 1937. College Entrance Book Company, 104 Fifth Avenue, New York, N. Y.

College Physics, by Arthur L. Foley, Professor of Physics, and Head of the Physics Department, Indiana University, Bloomington, Indiana. Second Edition. Cloth. Pages v+777. 14.5×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price \$3.75.

An Advanced Course in General College Physics, by Paul Leverne Bayley, Associate Professor of Physics, Lehigh University and Charles Clarence Bidwell, Professor of Physics, Lehigh University. Cloth. Pages v+340. 13.5×21.5 cm. 1936. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.50

College Physics, by John A. Eldridge, Professor of Physics, University of Iowa. Cloth. Pages x+616. 13.5×21.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$3.75.

Mathematics and Life, Book One, by G. M. Ruch, F. B. Knight and J. W. Studebaker. Cloth. 480 pages. 12.5×19 cm. 1937. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price 88 cents.

Technical Drawing for High Schools, Work Books I and II by E. L. Williams, Head of Department of Industrial Education, and H. C. Spencer, Assistant Professor of Engineering Drawing, Agricultural and Mechanical College of Texas. 50 pages. Paper. 21.5×28 cm. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 96 cents each.

Essential Experiments in General Science, Part I and Part II by Herschel N. Scott, Chairman, General Science Center, North Side High Schools, Chicago. Paper. 64 pages. 19.5×27 cm. 1937. Beckley-Cardy Company, 1632 Indiana Avenue, Chicago, Ill. Price 50 cents each.

A Textbook of Physics, by Louis Bevier Spinney, Professor of Physics, Iowa State College. Fifth Edition. Cloth. Pages xii+721. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.75.

Higher Algebra, by S. Barnard, Formerly Assistant Master at Rugby School, Late Fellow and Lecturer at Emmanuel College, Cambridge, and J. M. Child, Formerly Lecturer in Mathematics in the University of Manchester, Late Head of Mathematical Department, Technical College, Derby. Cloth. Pages xiv+585. 13.5×21.5 cm. 1936. Macmillan and Co., Limited, St. Martin's Street, London. Price \$6.00.

Mathematics in Life, by Raleigh Schorling, Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan, and John R. Clark, The Lincoln School, Teachers College, Columbia University. Cloth. Pages x+437. 15×24 cm. 1937. World Book Company, Yonkers-on-Hudson, New York, N. Y. Price \$1.40.

Mathematical Snack Bar, by Norman Alliston. Cloth. Pages vii+155. 13.5×21.5 cm. 1936. Chemical Publishing Company, 148 Lafayette Street, New York, N. Y. Price \$3.00.

Chemical Arithmetic, by F. W. Goddard, Senior Science Master, The College, Winchester. Cloth. Pages vii+99. 12×18 cm. 1937. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price 65 cents.

The National Council of Teachers of Mathematics, The Twelfth Yearbook, Approximate Computation, by Aaron Bakst, Ph.D. Cloth. Pages xvi+287. 14.5×23 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price \$1.75.

Projective Geometry, by Boyd Crumrine Patterson, Professor of Mathematics, Hamilton College. Cloth. Pages xiii+276. 14×21.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$3.50.

Mathematics of Finance, by D. H. Mackenzie, Assistant Professor of Accounting and Management, University of Washington, including Compound Interest and Annuity Tables, by F. C. Kent and M. E. Kent. First Edition. Cloth. Pages ix+214. 15×23 cm. 1937. The McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price \$3.75.

New World of Chemistry, by Bernard Jaffe, Chairman, Department of Physical Sciences, Bushwick High School, New York City. Cloth. Pages xii+566+xxx. 13.5×19.5 cm. 1937. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price \$1.80.

Carl Friedrich Gauss. Inaugural Lecture on Astronomy and Papers on the Foundations of Mathematics, translated and edited by G. Waldo Dunnington. Cloth. Pages xi+91. 12.5×19 cm. 1937. Louisiana State University Press, Baton Rouge, Louisiana. Price \$1.00.

The World and Man as Science Sees Them, edited by Forest Ray Moulton. Cloth. Pages xix+533. 15×23 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price \$3.00.

Arithmetic for Teacher-Training Classes, E. H. Taylor, Head of the Department of Mathematics, Eastern Illinois State Teachers College. Revised Edition. Cloth. Pages vii+432. 12.5×19 cm. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price \$1.70.

Lecture Experiments in Chemistry, by G. Fowles. Cloth. Pages xvi+564. 13.5×21 cm. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price \$5.00.

Foundations of College Physics, by Samuel Robinson Williams, Professor of Physics, Amherst College. Cloth. Pages x+630. 15×23 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price \$4.00.

How to Make Electric Toys, by Raymond F. Yates, Cloth. Pages xvi+199. 12.5×19 cm. 1937. D. Appleton Century Company, 35 West 32nd Street, New York, N. Y. Price \$2.00.

Man's Physical Universe, by Arthur Talbot Bawden, College of the Pacific, The Stockton Junior College. Cloth. Pages xvii+812. 14×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$3.50.

Tricks, Toys, and Tim, by Kreigh Collins. Cloth. Pages xii+238. 13.5×19 cm. 1937. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price \$2.00.

Principles of Quantum Mechanics, by Alfred Landé, Professor of Physics in the Ohio University. Cloth. Pages xii+115. 13.5×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$2.25.

Manual of Mathematics and Mechanics, by Guy Roger Clements, Professor in the Department of Mathematics, United States Naval Academy, and Levi Thomas Wilson, Professor in the Department of Mathematics, United States Naval Academy. First Edition. Cloth. Pages vii+266. 15×23 cm. 1937. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price \$2.50.

Chemistry and Cookery, by Annie Louise Macleod, Dean of the College of Home Economics, Syracuse University, and Edith H. Nason, Professor of Foods, Syracuse University. Second Edition. Cloth, Pages xiv+568. 14×20 cm. 1937. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price \$3.50.

High School Teachers' Methods, by Charles Elmer Holley, Formerly Head of the Department of Education, James Millikin University; sometime Professor of Secondary Education at the University of Idaho. Cloth. Pages vii+514. 14×21.5 cm. 1937. Garrard Press, 119-123 West Park Avenue, Champaign, Ill. Price \$3.00.

Preview of Mathematical Analysis, by Aaron Freilich, Chairman, Department of Mathematics, Bushwick High School, New York; Henry H. Shanholt, Chairman, Department of Mathematics, Abraham Lincoln High School, New York; and Joseph P. McCormack, Chairman, Department of Mathematics, Theodore Roosevelt High School, New York. Paper. Pages v+137. 13×18.5 cm. 1937. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price 60 cents.

Random Variables and Probability Distributions, by Harold Cramer, Professor in the University of Stockholm. Cambridge Tracts in Mathematics and Mathematical Physics, No. 36. Paper. Pages viii+120. 13.5×22 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$2.25.

American Red Cross First Aid Text-book, prepared by the American Red Cross for the instruction of First Aid Classes. Revised with 114 illustra-

tions. Paper. Pages xi + 256. 12.5 × 19.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Pa. This book may be had in paper covers at 60 cents or in cloth at \$1.00.

Workbook to General Science for Today, by Ralph K. Watkins, Professor of Education, University of Missouri, and Ralph C. Bedell, Professor of Education, State Teachers College, Kirksville, Missouri. Paper. Pages iii + 144. 20 × 28 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 60 cents.

Practical and Theoretical Photography, by Julian M. Blair, Associate Professor of Physics, University of Colorado, Boulder, Colorado. Second Edition. Paper. 112 pages. 20 × 27 cm. 1935. Julian M. Blair, Department of Physics, Boulder, Colo.

Thirty-eighth Annual Report of the Superintendent of Schools, City of New York, by Superintendent, Harold G. Campbell. Paper. 134 pages. 28 × 35.5 cm. 1935-36. Hall of the Board of Education, 500 Park Avenue, Manhattan, N. Y.

BOOK REVIEWS

Laboratory Methods of Organic Chemistry, by L. Gattermann, completely revised by Heinrich Wieland. Translated from the twenty-fourth German edition by W. McCartney, Ph.D. (Edin.), A.I.C. Late Assistant in the department of medical chemistry, University of Edinburgh. Pp. xvi + 435. 16 × 22.5 × 3 cm. Fifty-nine illustrations. Cloth. 1937. The Macmillan Co.

This well-known organic laboratory text (for it is much more than a manual) still continues, in this new edition, to give much space to the task of endeavoring to give the student a "command of methods" together with "an understanding of their rationale and a power of adapting their numerous modifications to particular requirements," as the preface to the nineteenth edition announced.

In order to bring the work up to date without too greatly increasing its size the dropping of numerous "examples" was resorted to. Among the new methods which have been introduced are "analysis by *chromatographic adsorption*" and the *ozonization* of unsaturated compounds. The section on analytical methods has been completely rewritten in view of the progress which has been made in the use of what the revisor calls "meso-analytical" methods (he does not like the term "half-micro.").

It is interesting to note that a reprint of the English edition of the book has appeared and that it has been translated into Russian and that an Italian translation is in course of preparation.

Organic chemistry teachers should ask to see this revision.

FRANK B. WADE

A Laboratory Guide to the Study of Qualitative Analysis, by E. H. S. Bailey, Ph.D., Late Professor of Chemistry in the University of Kansas and Hamilton P. Cady, Ph.D., Professor of Chemistry in the University of Kansas. Tenth Edition revised by Arthur W. Davidson, Ph.D., Associate Professor of Chemistry in the University of Kansas in collaboration with the junior author. Pages xiii + 322. 2.5 × 16 × 22 cm. Water resisting cloth. Blakiston.

Quoting from the preface, "In the present edition of this book, the theo-

retical introduction has been almost entirely rewritten, in order to present the modern viewpoint in this field to students of qualitative analysis. The distinction between strong and weak electrolytes has been sharply drawn; the former are regarded as practically completely dissociated in dilute aqueous solution, and the limitations to the applicability of the law of mass action, in the case of equilibria involving ions, are briefly discussed."

The first thirty-seven pages are devoted to theoretical considerations. The following two hundred pages are devoted to preliminary experiments for each of the cations and anions. The cations are studied in the order of alkali metals, alkaline earths, the ammonium sulfide group, etc. The right hand page is vacant and is to be used for notewriting. The directions for the preliminary experiments are more explanatory than directional. One wonders what the student is to find out for himself. Organized schemes for the separation and detection of the cations and anions are at the end of all the preliminary experiments. No appendix but an index.

Teachers of large laboratory classes with an inadequate number of assistants will probably find this book admirably suited to their needs.

DRULEY PARKER

College Physics, by Arthur L. Foley, Professor of Physics, and Head of the Physics Department, Indiana University, Bloomington, Indiana. Second Edition. Cloth. Pages v+777. 14.5×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price \$3.75.

A textbook that has received almost unanimous approval requires little alteration. The second edition of Foley's *College Physics* shows very few changes in content or order. The sequence has been improved in the chapters on motion; the sections on refraction phenomena, interference, and diffraction have been materially changed by the addition of topics on optical instruments and by a new grouping of topics; the final chapter on recent developments has been expanded and strengthened.

The most important alteration is in the lists of problems. These have been improved by elimination of some of the more difficult ones and those hard to interpret, by a more careful selection of problems so as to focus attention on physical principles rather than on mathematical processes, by the addition of many new problems. The book has also been made more durable and attractive by a waterproof binding and by improvements in typography.

Judging a textbook by means of an examination only a few hours in length is like attempting to judge a cake without tasting it. The only satisfactory criterion of a text is its helpfulness to students and teacher. In classes where the Foley has been used only for reference, the reviewer has found many of his students making more frequent use of this book than any other reference text, some of them studying it more consistently than their adopted text. Students in all courses using the Foley as the adopted text have pronounced it understandable, interesting, and sufficiently comprehensive for all their needs.

G. W. W.

College Physics, by John A. Eldridge, Professor of Physics, University of Iowa. Cloth. Pages x+616. 13.5×21.5 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$3.75.

This book differs in many respects from the typical or standard text book of physics for college students. In the first place the arrangement of subject matter is different. After introductory chapters intended to give

the student a glimpse of the field of physics and its relation to the things which surround him in daily life, the book discusses briefly the general properties of matter and elasticity. Then follow chapters on liquids and gases instead of the sections on force and motion as in the so-called logical arrangement. This sequence permits the student to start the subject with more or less familiar phenomena which can be readily demonstrated, rather than forcing him at once into a new and more difficult field of thought. The second important variation from the standard method of presentation is based on the assumption that the book will be used by many students who have little or only a general interest in the subject. To create interest new concepts are introduced by use of descriptive matter based on experiences from daily life, where this is possible, or on demonstrations designed to create interest and provide the needed experience. The more precise mathematical or technical presentation then follows the more general discussion.

The text is considerably smaller than many of the textbooks in common use. Also numerous topics are starred and may be omitted without destroying the continuity. This makes the book easily adaptable for classes desiring a short course and still provides the starred technical topics for physics majors. To many teachers this text may seem superficial and incomplete because it does not emphasize the analytical development of laws, omits many topics usually found, and provides only a very limited number of numerical problems for solution. The text was probably not intended for classes composed entirely of engineering students already familiar with some of the fundamentals and with the language of physical science. For the average class in general physics composed of liberal arts students the book seems admirably adapted because it presents the fundamental concepts in an interesting and effective style. For mixed classes it is easier to supply the supplementary material for the technical students than to modify a technical course to satisfy and inspire general students. The reviewer believes with the author that "physics can be a thrilling adventure and a good deal of fun," and that the course is a failure if the student learns to pass an examination but does not acquire an abiding interest in the subject.

G. W. W.

A Class Book of Magnetism and Electricity, by H. E. Hadley, Associate of the Royal College of Science, London, and Principal of the School of Science, Kidderminster, England. Pages x+512. 12.5×18.5 cm. 1936. Macmillan and Co., Limited, St. Martin's Street, London, Price \$2.50.

This text was written to provide a course for secondary school students who wish to prepare for entrance examinations in the technical courses of the universities of England and Scotland. In degree of difficulty it lies midway between our high school texts and the average introductory electrical texts of our own universities. The book, clearly written by one who is obviously conversant with both his subject and the secondary school student, should make a fine reference for the best of our physics students in high school and for the beginners in technical courses in our universities.

The text is compact and comprehensive in treatment, illustrated with neat line drawings and half-tone pictures. Historical notes occupy several pages at the end of each chapter except in the last few chapters where they are incorporated in the text matter dealing with modern applications. Throughout the book applications are introduced but fundamental principles are stressed at all times. Questions and problems supplement each chapter and numerical answers are given in the appendix.

The text is interesting. In the chapter, "The Dynamo: Distribution of

Power," is given an account of England's power network into which all power plants feed with the resultant economy of operation. In the chapter on electrical energy some stress is placed on the kilowatt-hour, there referred to as the "Board of Trade Unit." A discussion of early non-electrical telegraphs introduces the chapter on electrical communication. Beam transmission of radio waves is quite fully treated without making it too technical. The last chapter is entitled: "Sound Recording, Talking Films, Television." Steel tape recording is illustrated as well as the principles of the two common sound cameras, theatre sound projection, and picture telegraphy.

A. H. GOULD

Senior Science, by George L. Bush, Assistant Principal, South High School, Formerly Head of the Science Department, John Adams High School, Cleveland, Ohio; Theodore W. Ptacek, Instructor of Science, John Adams High School, Cleveland, Ohio; and John Kovats, Instructor of Science, John Adams High School, Cleveland, Ohio. Cloth. Pages vii + 835, 15 × 23 cm. 1937. American Book Company, 360 North Michigan Avenue, Chicago, Ill. Price \$2.20.

This book marks another ambitious attempt to survey a great field of knowledge, the Physical Sciences. It is indeed a notable venture in socialized science. The book "cuts boldly across subject-matter lines, stresses applications rather than theory, and directs special attention to the social implications of the subject matter."

The text is not an "over grown" general science. It is written for fourth year students who would otherwise not elect physics or chemistry. Since science plays such an important part in our lives, the authors have assumed the task of training the student in the use and implication of scientific principles that he may understand how these affect his social and economic life. This objective distinguishes the text from that used in general science courses.

The text is divided into ten topics: Water, Fire, Fuels, Weather and Air, Foods and Medicine, Textiles, Building Materials, Home Equipment, Transportation Safety. Interspersed throughout each topic are suggested questions for class discussion and individual library research projects. A commendable feature of the text is the candid treatment of consumers' problems.

In placing so much interesting and practical information into a single volume, the science behind the application has been neglected. A few erroneous statements of scientific principles will be found. If the text is supplemented with well-planned demonstrations, this error can be overcome.

Because of the size of the print, which in itself is very commendable, the book has assumed unduly large portions. This is a factor which must be considered in high-school texts. Aside from this the book has an attractive format. Much thought has gone into the selection of photographs.

C. RADIUS

A Textbook of Physics, by Louis Bevier Spinney, Professor of Physics, Iowa State College, Ames Iowa. Cloth, Pages xii + 721. 14 × 21 cm. 1937. Macmillan Company, New York. Price \$3.75.

This is a fifth edition of the text which was originally published in 1911. The well written treatment of Mechanics and Heat is the outstanding feature which was carried this text through so many years of use. The new edition includes a new chapter on thermal expansion. The student should

find no special difficulty in following the mathematical treatment in these sections. No use is made of the calculus in discussion or in derivation of formulas.

The work which normally constitutes the second semester of College Physics is typically "classical." Except for a sentence scattered here and there, the physics of the last two decades has made no impression on the treatment of these topics. To be sure, Modern Physics is in a state of transition. However, why can not electrolysis be discussed in the light of established facts? Here as in electrostatics there is a wonderful opportunity to develop a value of e/m without doing violence to one's adherence to classical physics. As a matter of fact such topics reiterate and amplify the old. Whatever mention is made of established facts of modern physics is relegated to a brief chapter.

One is indeed intrigued by the title *Corpuscles, Ether Waves, and Quanta*, the first chapter on light. After a single page discussion of these three points of view, the remaining pages take up mirror and lens formulas. The new edition also contains a chapter in which vacuum tubes are mentioned.

C. RADIUS

Practical Physics for Inter B.Sc. Students, by H. M. Browning, M.Sc., Ph.D., F.Inst.P., and L. Starbuck, B.Sc., A.Inst.P. Cloth. Pages x+146. 12×18 cm. 1936. Blackie & Son Limited, London and Glasgow. Price 3s. 6d. net.

This text corresponds to our manual of experiments for College Physics. It is written specifically for the London Intermediate Science examinations. To justify its use here, it must be able to replace one of our texts. The text can very well be used as a manual for the college physics laboratory. It is adapted to the needs of engineering students.

The practical details of the experiments are described and only enough theory is introduced to give the student an insight into the object of the experiments. All the experiments are of a quantitative nature. For this reason electrostatic is omitted.

C. RADIUS

Plane Trigonometry, by K. B. Patterson and A. O. Hickson, Duke University, Durham, North Carolina. Cloth. Pages ix+219. 13×20 cm. 1936. F. S. Crofts & Co. New York. Price \$1.75.

The organization of the material in this text is standard. Throughout the text the authors have kept in mind that this subject is not an end in itself, but a tool to be used in other branches of mathematics and engineering. Analytical and theoretical trigonometry have been given major importance. The student is encouraged not to think of trigonometry solely in terms of the solution of the oblique triangle. As the authors point out, the theoretical part of this subject is the practical part. This is justified since trigonometry should never be used as a terminal course in mathematics. Originality in the creation of exercises is encouraged. Blanks pages are included throughout the text for this purpose.

The text contains no tables of any kind.

C. RADIUS

Plane Trigonometry, by Edward S. Allen. Cloth. Pages viii+152. 1936. McGraw-Hill Book Company, 330 West 42nd St. New York, N.Y.

This text is attractive, but similar in most respects to other texts in the

same field. The author takes up first vectors and their addition, angles and their addition. This is followed by the definition of the radian, which he uses to a great extent throughout the text. In the second chapter he discusses the trigonometric functions based on similar right triangles. The book is adapted to McGraw-Hill Six place tables. There are no logarithm tables in the text. The text is comprehensive but not too large to be mastered in one course. The answers are intentionally omitted to alternate problems.

ARTHUR P. O'MARA

Individualizing Education, by J. E. Walters, Director of Personnel, Schools of Engineering, and Professor of Personnel Administration, Purdue University. Cloth. Pages xvi + 278. 14.5 × 22.5 cm. 1935. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price \$2.50, plus postage.

This is a practical book dealing with personnel methods. It presents the methods of individualizing education by means of applied personnel procedures and techniques of dealing with students from the grammar school level to the college level inclusive. No attempt is made to analyze critically personnel administration, but rather to show in a concrete way how personnel methods can be used. Many interesting techniques are described and should prove very helpful in working with students.

The book is divided into three parts. The first part is exceedingly valuable as a handbook for teachers and others who have charge of counselling in matters pertaining to student personnel and personality adjustment.

The second part deals with the description of a guidance bureau and should prove helpful to those who need a pattern for the organization of such a bureau.

The third part of the book describes personnel methods that have been successfully used and which can also be employed by the classroom teacher. In these days when guidance and counselling are being stressed in all forward looking school systems a book of this nature is indeed a valuable contribution to the field.

CHAS. A. STONE

Psychology of Adolescence, by Luella Cole, Ph.D. Cloth. Pages xvi + 503. 14 × 21.5 cm. 1936. Farrar and Rinehart, Inc., New York, N. Y. Price \$3.00.

This is perhaps the most readable textbook in the field of adolescent psychology that has yet appeared. The author has a facility of expression and a clear running style that is almost unknown in textbooks. The organization of content matter is characterized by a continuity from chapter to chapter that leaves an impression of totality and unity upon the reader. The book is extremely practical and comprehensive in content and presentation.

At the close of each chapter, numerous illustrative case studies are found. These not only are effective in motivating the study of the text; they also offer the teacher an opportunity to introduce case study analysis into his course in the Psychology of Adolescence in keeping with the present trend in the teaching of all Psychology and Sociology courses. A good bibliography of recent books, many of which are collections of case studies, is to be found at the end of each chapter. Since all of these are referred to in the text, they comprise a closely knit body of correlated reading.

The basis of the book is educational rather than psychological; it seems to be directed frankly towards teachers rather than psychologists. Con-

tributions of Psychoanalysis and the individual psychology, for example, are somewhat neglected although they are very pertinent to the student of adolescence. The presentation is empirical and pragmatic rather than historical and theatrical, and while this by no means detracts from the value of the book, some supplementation with historical and theatrical aspects of the field is indicated. Furthermore, the chapter entitled *The Emotional Deviate*, excellent for the teacher, might cause some concern to the psychologist. Certain distinctions, such as that between hysteria and what is popularly known as hysterical behavior, and between neurasthenia psychasthenia, are not drawn. This reviewer, however, believes that, in the light of her purpose, the author could not have handled the chapter any more felicitously than she did. Extreme nervous cases are not usually found in school—they are home or in the hospital. The teacher therefore, needs a knowledge of the symptoms of general nervous disorders, rather than of specific ones.

The book should be invaluable as one of the basic texts in a course of study in adolescent psychology. If a high-school teacher, or an intelligent parent is looking for a complete, practical, and interesting treatment of adolescence in one book, Cole's is the first to which he would do well to turn.

WILLIAM J. SANDERS

The Wonderful Wonders of One—Two—Three, by David Eugene Smith. Cloth. 47 pages. 15.5×22 cm. 1937. McFarlane, Warde, McFarlane, Inc., 6 East 45th Street, New York, N. Y.

This book should find favor among teachers, parents, and children as a source of supplementary reading in arithmetic. Those familiar with Dr. Smith's "Number Stories of Long Ago" may anticipate even greater popularity for his recent publication. The author relates in story form some of the outstanding events in the history of numbers. Some of the important topics described are Roman numbers, place value, the largest number, magic squares and circles, curious sums and products, how numbers got their names, and numbers existing in nature. The book is cleverly illustrated and attractively bound.

L. C. WARNER

How to Use the Educational Sound Film, by M. R. Brunstetter, Director, Bureau of Publications, Teachers College, Columbia University. Cloth. Pages xiii + 174. 15.5×22 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price \$2.00.

Within recent years educational sound films have become recognized as an effective aid to the learning process. This book is composed of six chapters and two appendixes. The first four chapters discuss the utilization, technique of presentation, and the organization of an audio-visual education program. The last two chapters discuss the manipulation and mechanical aspects of sound film machines. The appendixes contain an outline of a typical unit on running water taught with a sound film and a discussion of the integration of sound films with elementary school science. The book should prove a helpful guide to teachers having sound film equipment available and to administrators contemplating a visual-audio education program.

L. C. WARNER

HINTS FOR THE CHEMIST'S SECRETARY

BY RALPH E. DUNBAR

Iowa State College, Ames, Iowa

In addition to the preparation of the office supply of ink, paste, glue, ink eradicator, sealing wax and similar items, the following suggestions may be found to be helpful in conducting the routine office work of any chemistry office.

1. Rubber stoppers may be successfully substituted for pencil erasers.
2. Small elastic rubber bands may be cut from light wall rubber tubing or rubber tubing for Gooch Crucibles. The size will vary with the diameter of the original tubing and with width of the cut.
3. Crystallizing dishes and watch glasses make suitable containers for paper clips, pens, pins and similar small items.
4. Filter paper makes a suitable substitute for blotters, the heavier varieties being superior in absorbing properties.
5. A Soxhlet extraction thimble, slipped over the finger like a thimble, makes even a more convenient blotter, especially when recording grades or similar items where a large number of cards and papers must be repeatedly handled and the use of the ordinary blotter becomes cumbersome. The Soxhlet thimble may be cut down to any convenient size.
6. A steel spatula makes a suitable letter opener, or knife for ink erasures when used as the ordinary pocket knife.
7. A wing shape rubber policeman, slipped over the end of a glass rod, makes a suitable brush for the spreading of paste.
8. Convenient desk lamps may be improvised with the usual laboratory extension cords, ring-stands and clamps.
9. A small laboratory balance makes a convenient substitute for the ordinary postal scales.
10. A small Erlenmeyer flask, snugly stoppered with absorbent cotton, makes a suitable moistener for stamps and envelopes.

MICROSCOPE POLARIZERS

Polaroid attachments for standard laboratory microscopes, made available only recently, provide the student, teacher and research worker with an inexpensive method for study and exploration in biology, chemistry, petrography and industry.

The attachments consist of an analyzer and a polarizer. A thin layer of the patented Polaroid material is accurately mounted in each. It is fixed between clear optical glass—ground and polished. In use, the polarizer is attached below the stage of the microscope and the analyzer fits over the eyepiece.

The analyzer consists of a lower supporting ring and a Polaroid cap to fit over the ocular of the microscope. On removing the ocular, the supporting ring slides onto the upper end of the microscope tube. The ocular being replaced, the Polaroid cap then fits firmly and rotates freely over the supporting ring. The aperture of the analyzer is 11 mm.

The polarizer is a Polaroid disc, set in a duraluminum rim and has an aperture of 23 mm. This slips into the sub-stage "blue glass ring" below the condensing lens of the microscope.

The recent revival of interest in polarized light is further enhanced by these new devices which are well worth the price of \$10.00 per set. When ordering the attachments, it is necessary to state the make of your microscope.—*The Laboratory*, Fisher Scientific Co.